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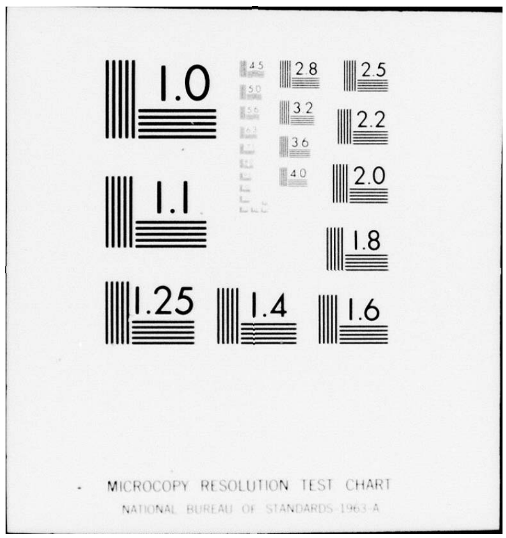
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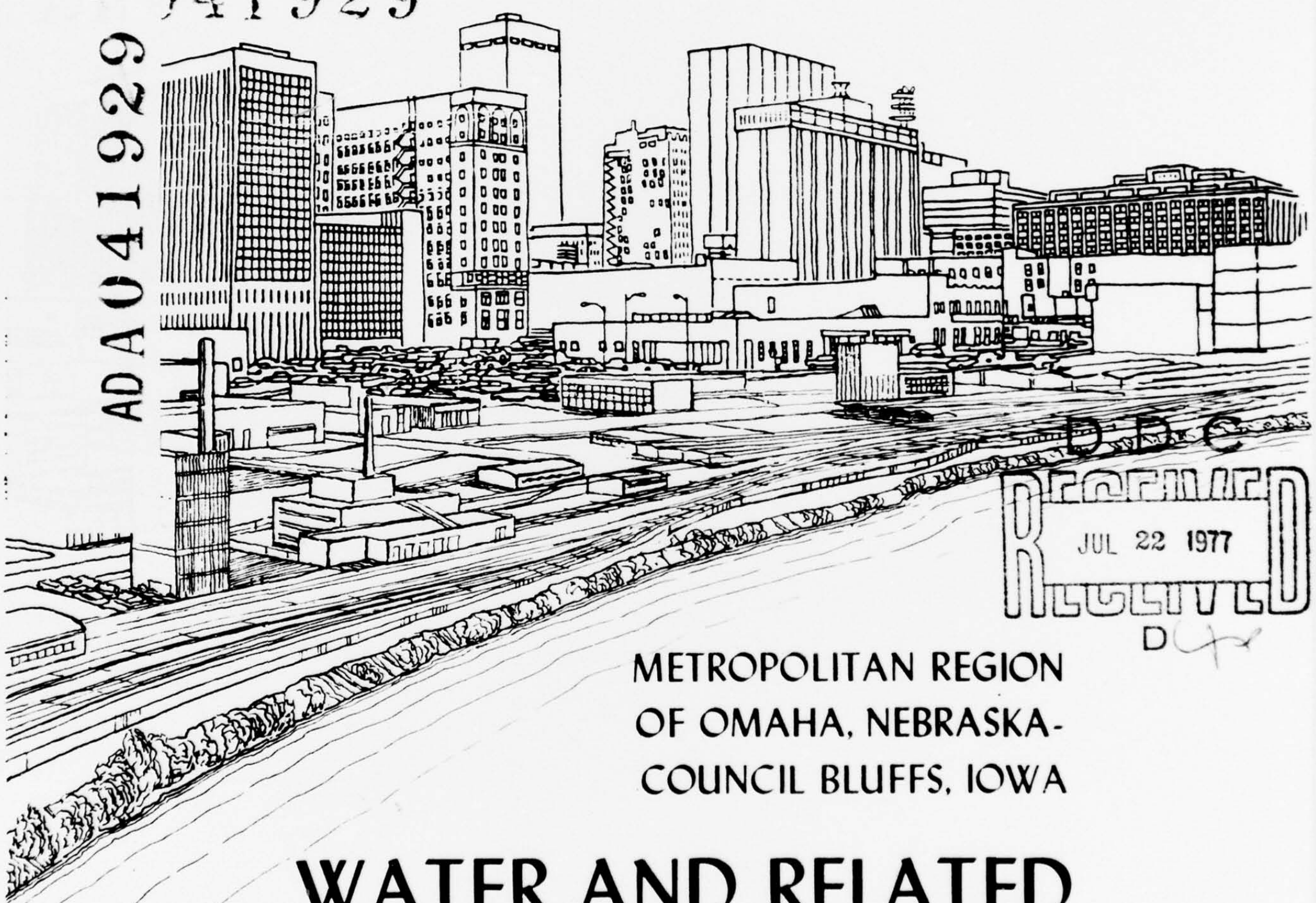
SUPPORTING TECHNICAL REPORTS APPENDIX

ANNEX C- URBAN STORMWATER HYDROLOGIC STUDY

REVIEW REPORT ON THE MISSOURI RIVER AND TRIBUTARIES



METROPOLITAN REGION
OF OMAHA, NEBRASKA-
COUNCIL BLUFFS, IOWA

WATER AND RELATED LAND RESOURCES MANAGEMENT STUDY

JUNE 1975

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URBAN STORMWATER HYDROLOGIC STUDY

OMAHA DISTRICT, CORPS OF ENGINEERS

This paper describes the basic urban stormwater hydrologic study performed by the Omaha District, Corps of Engineers, for the Omaha-Council Bluffs Urban Study.

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(6) Water and Related Land Resources Management Study. Volume V. Supporting Technical Reports Appendix. Annex C. Urban Stormwater Hydrologic Study.

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PART I - ALTERNATE PLANS FOR ABATEMENT OF POLLUTION FROM COMBINED SEWER OVERFLOWS.

1. Omaha-Missouri River Sewerage System and Treatment Plant. The Harza Engineering Company, located in Chicago, Illinois, was selected to perform the engineering services necessary to provide alternate abatement plans for the combined sewer overflow problems associated with the Omaha-Missouri River sewerage system. The study area contains approximately 22,000 acres of urban land located in the eastern portion of Omaha, Nebraska between the Papillion Creek basin and the west bank of the Missouri River. Within the area, stormwater and dry-weather discharges are conveyed by a network of combined sewers which flow by gravity towards the Missouri River. The combined flows are then collected and diverted by the north and south interceptor sewer to the Omaha-Missouri River Sewage Treatment Plant. The interceptor system is located parallel to the Missouri River and was designed to have a hydraulic capacity related to the ratio of the stormwater flow to the design dry weather flow. The north interceptor was designed for a 5 to 1 ratio and the south interceptor was designed for a 3 to 1 ratio. When combined flows exceed the capacity of the interceptor or when mechanical breakdowns occur at the lift stations, untreated sewage overflows into the Missouri River at one or all of the 20 discharge points located within the study limits. Two large combined sewers, namely the South Omaha and Monroe Street sewers, discharge directly to the treatment plant; when overloaded, however, a portion of the untreated sewage may bypass the treatment plant and overflow into the river. The Omaha-Missouri River

Sewage Treatment Plant presently has a primary treatment hydraulic capacity of 72 mgd and a proposed secondary treatment capacity of 65 mgd.

2. Stormwater Hydrologic Analysis. The basic hydrologic analysis used in the study for the stormwater portion of the combined sewage flow was accomplished by the Omaha District, Corps of Engineers. This analysis included computation of the design peak discharges and runoff volumes for each of the 18 sewer service areas comprising the entire study drainage area. The following paragraphs discuss the hydrologic criteria and the stormwater analysis.

a. General. This study was completed for the Missouri River combined sewage treatment facilities and it contains a hydrologic analysis of the 18 sewer service areas shown on Plate 1. Design discharge frequency relationships, the 1, 2, 5, 10, and 25 year design storm hydrographs and the respective maximum 1, 6, and 24 hour runoff volumes were developed for 17 of the sewer service areas. For the remaining sewer service area, namely Carter Lake, the computations included the maximum 1, 6, and 24 hour runoff volumes for the 1, 2, 5, 10, and 25 year design storms. A summary of the computed design discharges and runoff volumes are shown on Plate 2. The 18 sewer service areas comprise the entire surface runoff drainage area for the combined sewer collection system tributary to the Omaha-Missouri River Sewage Treatment Plant. Development of the design hydrologic discharges was based on existing land use patterns; these patterns were determined from aerial photographs taken in July 1972. Natural surface runoff drainage area boundaries do not

in all cases correspond with the sewer service area boundaries but officials of the Omaha Public Works Department stated that the manmade boundaries imposed by the collection facilities would contain the flows by ponding at the sewer inlets. It was, therefore, assumed that these boundaries would be valid up to the 25 year design limit of this study. It must be recognized that for more extreme events, it is possible that a portion of the runoff would overtop the manmade boundaries and discharge according to the natural topography.

b. Sewer Service Areas. Pertinent hydrologic characteristics for the 18 sewer service areas are summarized on Plate 2. Drainage area sizes, maximum flow distances, and average land slopes were determined from United States Geological Survey Quadrangle Maps (scale: 1 inch = 2,000 feet and a contour interval of 10 feet). Seventeen of the sewer service areas are drained by gravity in combined sewers that convey flow in an easterly direction towards the Missouri River. The 20 major outlets for the 17 areas discharge into a pressurized interceptor sewer that parallels the river and conveys the flows downstream to the sewage treatment plant. When discharge from the sewer service areas exceeds the capacity of the interceptor, the entire flow is overflowed directly into the Missouri River. The 17 service areas tributary to the west side of the interceptor sewer consist of approximately 33 square miles. The Carter Lake sewer service area is tributary to the ast side of the interceptor sewer. This area is unique in that it is relatively flat, poorly drained, and the surface runoff does not necessarily enter the interceptor sewer coincident with the remaining 17 sewer service areas. The major portion of

the surface drainage discharges into Carter Lake which has a 300-acre surface area. The runoff is temporarily stored in the lake and is pumped into the interceptor sewer after the remainder of the system has drained. This sewer service area has two outlets and the drainage area consists of about 6.5 square miles.

c. Hydrologic Design Criteria. The peak discharge rate of the design storms for each sewer service area was computed by the Rational Formula $Q = C\ (I - F_{av})A$, where:

Q = peak runoff rate in cubic feet per second;

C = a runoff coefficient roughly representing the infiltration capacity of the pervious and impervious surfaces of the drainage area. C is expressed as the composite of the runoff coefficients, C(pervious) and C(impervious), from the pervious and impervious surfaces of the drainage area ($C_{comp.} = C_{per.}\ (P_p) + C_{imp.}\ (P_i)$ where P_p and P_i are the percent of pervious and impervious areas, respectively):

I = rainfall intensity in inches per hour for the critical time of concentration for each sewer service area:

F_{av} = available depression storage in inches per hour: and

A = drainage area expressed in acres.

The design storm point rainfall amounts were obtained from the rainfall-frequency-duration isopluvial maps contained in the U.S. Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas of the United States", May 1961. A tabulation of the design point rainfall amounts in the vicinity of Omaha-Council Bluffs for specific rainfall-duration-frequency storms is shown on Plate 3. These point rainfall amounts were adjusted to obtain the average depth over the entire 33 square mile

drainage area contained in the 17 sewer service areas. The tabulation of average-depth point rainfall amounts is shown on Plate 4. The runoff coefficient (C) for each area was weighted according to the watershed land use development, soil type, and land slopes. The C values for the pervious areas were adjusted for specific frequency events by Bernard's Equation, $C = C_{100} \left(\frac{F}{100}\right)^x$ where:

C = the adjusted C for a specific frequency event F;

C_{100} = the chosen runoff coefficient for the 100-year event;

F = the frequency of the desired event in years: and

x = a coefficient equal to 0.18 for the vicinity of Omaha.

The tabulation of the basic runoff coefficients used is shown on Plate 5. The discharge frequency curves were developed for each sewer service area by computing the peak discharge of the 1, 2, 5, 10, and 25 year storm events. The design storm hydrographs were developed using the following procedure: (1) the hydrograph peak discharges were computed using the Rational Formula; and (2) the hydrographs were sized and shaped using the time of concentration of each service area and the distribution and volume of runoff for each respective area which were determined from the hypothetical hyetographs. The hydrologic computations for the Grace Street sewer service area, which are typical of those developed for each of the remaining 17 sewer service areas, are shown on Plates 6 through 16.

3. Combined Sewage Overflows. Untreated combined sewage overflows to the Missouri River occur when the rate of runoff exceeds the capacity of the interceptor system. According to the Harza report, the interceptor capacity is exceeded whenever the rainfall intensity over the 22,000 acre drainage area reaches 0.10 inch per hour. Based on 20 years of rainfall record, the study indicated that overflows occurred on the average of about 50 times per year and the total average annual volume of overflow was about 5 billion gallons. The HEC Computer Program, Urban Storm Water Runoff "STORM", dated May 1974, was used as an independent tool to determine the average annual number and the quantity of overflows. This program provides a method to estimate the quantity of runoff from small urban drainage areas using the hourly precipitation record. The interaction between the treatment rates, storage capacity, and overflows from the treatment and storage system to the receiving water is investigated by a continuous simulation model using many years of hourly precipitation records. There is an official National Weather Service recording precipitation gaging station at Eppley Airfield, which is located within the Omaha-Missouri River Sewage Treatment Plant sewer service area. This station was used to provide the rainfall input for the "Storm" simulation model. A 24-year portion of the hourly long term record for the period 1949 to 1972 was obtained from the National Weather Service at Ashville, North Carolina. The average annual rainfall for this period was 30.46 inches compared to the long term average of 28.50 inches. The maximum annual rainfall for the 24-year period was 44.83 inches in 1965, and the minimum annual rainfall was 18.22 inches in 1953. The results of the

"Storm" model runs compare favorably with the Harza analysis. The input and output data for the simulation runs for the entire combined sewer service area are shown on Plates 17 through 30. The model output shown on Plate 18 indicates that, with a treatment rate of 0.01 inch per hour, overflows would occur on the average of 56.6 times a year and would result from an average annual runoff of 13.35 inches with 11.19 inches overflowing to the Missouri River. The 11.19 inches over the 22,000 acre drainage area would yield an average annual overflow volume of 6.7 billion gallons versus the 5 billion gallons estimated in the Harza report. Plates 19 through 30 present the average annual number and volume of overflows with a treatment rate of 0.01 inch per hour and storage capacities varying from 0.04 inch to 1.3 inches per acre. The curve of average annual number of overflows versus the storage capacity was plotted from these data and it is shown on Plate 31. This curve indicates that a storage capacity of about 1.25 inches per acre would have reduced the occurrence of overflows to one event per year. For the entire drainage area, this would require a storage area of about 2,290 acre-feet, which is approximately equal to the requirement of 1,964 acre-feet to contain the design 1-year, 24-hour runoff volume. The curve on Plate 32 shows the average annual inches of overflow versus storage capacity. This curve indicates that the greatest reduction in the volume of runoff overflows occurs throughout the steep portion of the curve, which includes about the first 0.5 inch per acre of storage capability. The overflow volume is reduced by 5.2 billion gallons, from about 6.7 to 1.5 billion gallons, whereas in the second 0.5 inch per acre of

storage, located on the flat portion of the curve, the reduction in overflow is only 1.0 billion gallons, from about 1.5 to 0.5 billion gallons. These curves indicate that a storage area capacity capable of controlling the design runoff for the 1 to 5 year recurrence interval would accomplish the major reduction in the annual number and quantity of overflows. It would, therefore, not be cost-effective to design for a more infrequent recurrence interval because the incremental cost to prevent additional overflow volume would be excessive.

PART II - OMAHA-COUNCIL BLUFFS REGIONAL WASTEWATER MANAGEMENT STUDY.

1. Hydrologic Analysis and Land Use Concepts. The regional wastewater management study includes the development of conceptual alternatives to reduce pollution emanating from urban and agricultural stormwater runoff. The hydrologic analysis prepared by the Omaha District, Corps of Engineers, for this study consisted of developing stormwater peak discharges and runoff volumes for drainage areas within the study area that are projected to be urban according to four alternative land use concepts. The four projected growth concepts for the Omaha-Council Bluffs urban study are referred to as Concepts A, B, C, and D. Concept A is basically a continuation of the present land use growth patterns. Concept B includes the controlled expansion and redevelopment of urban Omaha and the development of numerous urban satellite cities with the preservation of the intercity open space as a greenbelt area. Concept C is similar to Concept B but it does not include the satellite cities. Concept D assumes that urban growth patterns will occur as strips along major transportation corridors. Shown

on Plate 33 are the critical drainage areas affected by existing or future urban growth in one or more of the four alternative land use concepts. The drainage area delineations were established according to natural basin boundaries for the areas tributary to the natural streams and according to sewer service areas for the areas tributary to combined sewers. For those areas located in the Papillion Creek basin, the sub-areas are delineated according to the breakdown used in the "Papio" Hydrologic Model. The basic hydrologic parameters and the development of the "Papio" Hydrologic Computer Model are discussed in Part IV. The design stormwater, 6-hour runoff volume and the peak discharge for the 1, 5, and 10-year frequency events were computed for 61 individual basins, the drainage area boundaries are shown on Plate 33. This required 167 computations of runoff volume and peak discharge for each of the three design storms in order to determine the effects of the four different urban growth patterns within the 61 basins. Shown on Plate 34 is a tabulation of the stormwater design peak discharge and volume computed for each basin and listed according to frequency and respective land use concept.

2. Design Rainfall. The design point rainfall amounts shown on Plate 35 were taken from U.S. Weather Bureau Technical Papers Nos. 40 and 49. To determine the design rainfall depth for the entire 385 square mile Papillion Creek basin, the point rainfall amounts were reduced according to the percentages shown on the area-depth duration curves contained in Technical Paper No. 40. The resulting rainfall amounts for the entire basin are shown on Plate 36.

3. Stormwater Runoff Volumes and Peak Discharges. The runoff volumes were computed in a manner that will be compatible with using the HEC Computer Program Urban Stormwater Runoff "Storm" during the Phase II Study. The "Storm" Model will be used to determine the effectiveness of various proposed stormwater storage and treatment systems and to determine the magnitude of various critical water quality constituents contained in the stormwater runoff. The quantity of runoff is computed by multiplying a runoff coefficient "C" times the hourly precipitation. The selected runoff coefficients "C" for each frequency storm indicate the ratio of the design runoff to the design rainfall. The program then uses the Rational Formula, Q = CIA, to compute the peak discharge by multiplying the computed runoff times the drainage area in acres. The peak discharge computed in this manner would be valid only if the drainage area had a time of concentration equal to 1 hour, because the Rational Formula assumes that the entire area is contributing runoff during the time at which the rainfall is occurring at a uniform intensity. Because very few of the 61 drainage areas have a 1-hour time of concentration, it was determined that a more realistic peak discharge would be computed by applying the design storm runoff amounts computed with the "Storm" program to each of the individual basin unit hydrographs which are contained in the "Papio" Hydrologic Computer Model. For the Council Bluffs urban area, unit hydrographs were developed for Indian and Mosquito Creeks. In the development of the "Papio" Hydrologic Computer Model, the matter of determining the proper runoff values for the various probabilities was accomplished by using, as a guide, the computed discharge probability curves

at Fort Crook and Irvington, Nebraska. These curves were determined from the stream gage station on the Papillion Creek at Fort Crook, established in 1946, and the stream gage station on the Little Papillion Creek, established in 1948. The peak discharge record from each of these stations was analyzed using the methods outlined in "Statistical Methods in Hydrology" January 1962. The resulting curves with partial duration, top half analysis and expected probability are shown on Plates 37 and 38. The curves determined by applying expected probability to the computed top half analysis were selected because the values in the upper portion of these curves are more compatible with values from probability curves that have been computed for streams of similar size and characteristics in this region. Using the "Papio" Hydrologic Computer Model and the assumption of uniform runoff throughout the basin, computer runs were made to determine, for the various probabilities, the runoff amounts required to achieve reproduction of the computed probability curves at the two locations. The computed runoff values are summarized in Table 1.

TABLE 1
COMPUTED RUNOFF PROBABILITIES

PROBABILITY	LITTLE PAPILLION CR. AT IRVINGTON		PAPILLION CREEK AT FORT CROOK	
	Peak Discharge From Computed Curve (c.f.s.)	Required Runoff (inches)	Peak Discharge From Computed Curve (c.f.s.)	Required Runoff (inches)
10 Year	7,600	1.16	19,200	1.51
5 Year	5,300	0.80	14,200	1.03
1 Year	2,350	0.30	5,600	0.30

In general, the actual runoff amounts for similar probabilities agree; therefore, the average of the Irvington and Fort Crook values was used. The adopted runoff values are shown in Table 2.

TABLE 2
ADOPTED RUNOFF AND RAINFALL PROBABILITIES

Probability	Runoff (Inches)	6-Hour TP-40 Rainfall* (Inches)
10 Year	1.33	2.97
5 Year	0.91	2.57
1 Year	0.30	1.61

*Rainfall amounts taken from Plate 36.

The runoff coefficients "C" were then computed for use in the regional wastewater management study by determining the ratio of the adopted runoff to the TP-40 rainfall. The computation of the runoff coefficients for the 1, 5, and 10 year events is shown in Table 3. A runoff coefficient of 0.90 was used for the impervious areas.

TABLE 3
COMPUTATION OF PERVIOUS AREA RUNOFF COEFFICIENTS

1 YEAR

$$C_1 = \frac{\text{Runoff*}}{\text{Rainfall*}} = \frac{0.30}{1.61} = 0.19$$

5 YEAR

$$C_5 = \frac{\text{Runoff*}}{\text{Rainfall*}} = \frac{0.91}{2.57} = 0.35$$

10 YEAR

$$C_{10} = \frac{\text{Runoff*}}{\text{Rainfall*}} = \frac{1.33}{2.97} = 0.45$$

*Adopted runoff and rainfall amounts taken from Table 2.

Using the adopted pervious runoff coefficients, the 1, 5, and 10 year design runoff amounts were computed by applying the

composite coefficient for varying degrees of basin imperviousness to the design point rainfall amounts shown on Plates 39, 40, and 41, respectively.

4. Runoff and Peak Discharge Computations. Shown on Plates 42 through 55 are the drainage area input forms for each growth concept and the runoff volume and peak discharge calculations for the basin designated Little Papillion Creek No. 73 (LP-73). These calculations are typical of those developed for the remaining 60 drainage areas. The data input forms were used to calculate the average percent of drainage area imperviousness. They were developed by overlaying the four land use concept maps over the drainage area and plainimetering the area of each land use category, such as residential, commercial, and industrial. A percent of imperviousness was then assigned to each category based on projected population densities. The input forms are shown on Plates 42 through 45. The calculations consisted of determining the design runoff volume and peak discharge for each area according to the four future growth concepts. The runoff volumes were computed for each area by determining the composite runoff coefficient, according to the percent of imperviousness of the area, and applying the coefficient to the design hourly rainfall. These calculations are shown on Plates 46 through 49. The design peak discharges were computed by applying the design runoff to the 1-hour unit hydrographs for each basin. In those basins that are not completely urbanized, the unit hydrographs were reduced uniformly according to the percent of the total area projected to become urbanized. These typical calculations are shown on Plates 50 through 55.

5. Future Phase II Studies. The HEC "Storm" Model will be run to determine the effectiveness of the proposed stormwater detention structures by simulating their operation throughout a 24-year period of rainfall record. This Model will also be used to determine the average concentrations and loadings of the critical urban runoff water quality constituents. The "Papio" Model will be run to determine the flood control benefits attributable to the proposed stormwater detention structures located within the Papillion Creek basin. The Papillion Creek basin and the locations of proposed Corps of Engineers reservoirs are shown on Plate 56.

PART III - INDIAN CREEK AND MOSQUITO CREEK, COUNCIL BLUFFS, IOWA - GENERALIZED CURVES FOR SURFACE RUNOFF PEAK DISCHARGE RATE AND VOLUME VERSUS DRAINAGE AREA ASSUMING LAND USE PATTERNS VARYING FROM RURAL TO FULLY URBANIZED.

1. Hydrologic Analysis. A hydrologic study was conducted to determine the impact that potential urbanization would have on surface runoff volume and peak discharge rates within the Indian Creek and Mosquito Creek basins. These basins are both located in or near the metropolitan area of Council Bluffs. The Mosquito Creek basin map is shown on Plate 57. The present land use in this basin is primarily rural, about 2 percent of the area contains urban development. Within the Indian Creek basin, the Soil Conservation Service (SCS) has initiated the installation of an erosion control program. Officials with the SCS at Council Bluffs were contacted in order to obtain design information on the existing and proposed structural measures that would be constructed under this program. It was determined that present designs include the planned completion of 15 gully and erosion control structures; four have already been constructed. The

structures consist of earthen embankments or existing road embankments with drop-inlet or reinforced concrete chute type outlets and earthen spillways designed for full-flow conditions. Two of the erosion control structures incorporate detention storage for the purpose of flood control. These two structures are designed to handle the 50-year flood and each has approximately 150 acres of contributing area. The Indian Creek basin map with the SCS structure locations is shown on Plate 58. Overall determination of the SCS Project flood control effects was not considered in this study because the major structural purpose is erosion control and only two of the smaller structures have designated flood control storage. A more comprehensive analysis will be conducted at a later date for the Indian Creek flood plain studies, although it can be assumed that for high flows the flood control effects of the reservoirs would be very minimal.

2. Design Rainfall. The design point rainfall amounts were obtained from the rainfall-frequency-duration isopluvial maps contained in the reference: U.S. Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas of the United States," May 1961. Shown on Plate 3 is a tabulation of the point rainfall amounts in the vicinity of Omaha-Council Bluffs for specific duration-frequency storms. These point rainfall amounts were used for basins having drainage areas of 10 square miles or less. The point rainfall amounts were reduced by the percentages shown on the area-depth duration curves contained in Technical Paper No. 40 to obtain the average depth rainfall over basins varying in size from 10 to 240 square miles.

3. Indian Creek Hydrologic Analysis.

a. General. The hydrologic analysis consisted of computing a family of generalized curves of surface runoff volume and peak discharge rate versus drainage area. These curves indicate the potential effects of urbanization within the presently rural Indian Creek basin. A basin map is shown on Plate 58. These generalized curves were computed for the following three types of land use conditions: (1) the existing rural conditions; (2) potential residential usage varying from a large lot to dense type development; and (3) potential commercial usage varying from average to highly concentrated development. The existing condition rural curves were determined using the peak discharge frequency curve and the 1-hour unit hydrograph, both of which were computed from streamflow records at the Indian Creek gage location. The existing condition runoff amounts for various frequency storms were computed by dividing the respective peak discharge from the frequency curve by the peak discharge from the unit hydrograph. To determine the rainfall losses, the computed runoff amounts were subtracted from the design 1-hour point rainfall amounts shown on Plate 3. The computed runoff amounts shown in Table 4 were then smoothed in order for the loss rates to vary uniformly.

TABLE 4
EXISTING CONDITION DESIGN RUNOFF AMOUNTS
FOR AREAS OF 10 SQUARE MILES OR LESS
AND VARIOUS FREQUENCY STORMS

Storm Frequency	Peak Discharge From Frequency Curve (c.f.s.)	Peak Discharge From 1-Hour Unit Hydrograph (c.f.s.)	1-Hour Design Rainfall (Plate 3) (inches)	Computed 1-Hour Rainfall Loss (inches)	Computed 1-Hour Runoff (inches)
100 Year	10,500	3,700	3.60	0.75	2.85
50 Year	8,100	3,700	3.20	1.00	2.20
25 Year	6,200	3,700	2.85	1.20	1.70
10 Year	4,100	3,700	2.45	1.20	1.25
5 Year	2,800	3,700	2.10	1.20	0.90
2 Year	1,550	3,700	1.62	1.20	0.42
1 Year	560	3,700	1.35	1.20	0.15

The generalized existing rural condition curves were then constructed by applying the computed 1-hour runoff amounts to the synthetic unit hydrographs determined for basins varying in size from 0.5 square mile to 10.0 square miles. The existing condition curves are shown on Plates 59 and 60. The residential and commercial development curves were determined by increasing the computed existing runoff amounts according to the percentage of impervious surface assumed to be typical for each type of land use development. The estimated average percent of impervious surfaces for each land use type is shown in Table 5.

TABLE 5
AVERAGE PERCENT OF IMPERVIOUS SURFACES
ESTIMATED FOR SPECIFIC LAND USE TYPES

LAND USE TYPE	AREA IMPERVIOUS (percent)
Existing Conditions	
Rural	0
Residential Development	
Large Lot	30
Normal	40
Dense	52
Commercial Development	
Average	80
Highly Concentrated	95

The impervious surface runoff amount was calculated by applying a 0.10 inch depression and detention storage loss to the design rainfall. The composite runoff amounts for the various land use types shown in Table 6 were computed by weighting the total runoff according to the proper percentage of runoff from the pervious and impervious surfaces. The composite runoff amounts were applied to the unit hydrographs to develop the residential and commercial type land use curves shown on Plates 61 through 64.

b. Unit Hydrograph Derivation. A 1-hour unit hydrograph was derived from streamflow records of the 30 April 1951 storm at the Indian Creek gage location. This unit hydrograph has a peak discharge of 3,700 c.f.s. and Snyder's hydrograph coefficients of $C_t = 0.44$ and $C_p = 0.76$. These 1-hour coefficients were used to compute the unit hydrographs for subareas, varying in size from 0.5 square mile to 10 square miles, within the Indian Creek basin.

c. Discharge Probability Analysis. The discharge probability curve for the Indian Creek gage location is shown on Plate 65.

TABLE 6
RUNOFF AMOUNTS FOR VARIOUS FREQUENCY STORMS AND
SPECIFIC TYPE LAND USE DEVELOPMENT

Storm Frequency	Existing Conditions Rural 0% Impervious (inches)	Residential Development Large Lot 30% Impervious (inches)	Residential Development Normal 40% Impervious (inches)	Residential Development Dense 52% Impervious (inches)	Commercial Development Average 80% Impervious (inches)	Commercial Development Highly Concentrated 95% Impervious (inches)
100 Year	2.85	3.04	3.11	3.18	3.37	3.46
50 Year	2.20	2.47	2.56	2.66	2.92	3.05
25 Year	1.70	2.01	2.12	2.24	2.54	2.69
10 Year	1.25	1.57	1.69	1.82	2.13	2.29
5 Year	0.90	1.23	1.34	1.47	1.78	1.94
2 Year	0.42	0.74	0.85	0.99	1.29	1.46
1 Year	0.15	0.47	0.59	0.72	1.03	1.19

This curve was developed by the Log Pearson Type III distribution using 16 years of gaging records and estimates for the maximum discharges from four historical floods that occurred in the years 1923, 1942, 1947, and 1948. Since the first flood occurred in 1923, the two largest historical events were plotted on the basis of a 50-year record. Expected probability and partial duration adjustments were applied to the annual series frequency curve.

4. Mosquito Creek Hydrologic Analysis.

a. General. The hydrologic analysis consisted of computing generalized curves of surface runoff volume and peak discharge rate versus drainage area for the Mosquito Creek basin. This basin contains 240 square miles and is located just east of Council Bluffs. A basin map is shown on Plate 57. The generalized curves were computed for the following three types of land use conditions: (1) the existing rural conditions; (2) potential full residential usage with a normal type development; and (3) potential commercial usage varying from average to highly concentrated development. The existing condition curves were determined using the peak discharge frequency curve and the 1-hour unit hydrograph both of which were computed from streamflow records at the Mosquito Creek gage location. The existing condition runoff amounts for various frequency storms were computed by dividing the peak discharge from the frequency curve by the peak discharge from the unit hydrograph. The rainfall losses were then determined by subtracting the computed runoff amounts from the design 1-hour rainfall amounts. The design 1-hour rainfall was obtained by applying a depth area reduction of 67 percent to the point rainfall values shown on Plate 3. The computed runoff amounts shown in Table 7 were then smoothed in order for the loss rates to vary uniformly.

TABLE 7
EXISTING CONDITION DESIGN RUNOFF AMOUNTS
FOR A 240 SQUARE MILE AREA
AND VARIOUS FREQUENCY STORMS

Storm Frequency	Peak Discharge From Frequency Curve (c.f.s.)	Peak Discharge From 1-Hour Unit Hydrograph (c.f.s.)	1-Hour Design Rainfall Plate 3* (inches)	Computed 1-Hour Rainfall Loss (inches)	Computed 1-Hour Runoff (inches)
100 Year	36,000	18,000	2.40	0.40	2.00
50 Year	26,800	18,000	2.14	0.65	1.40
25 Year	19,000	18,000	1.90	0.85	1.05
10 Year	14,200	18,000	1.64	0.85	0.79
5 Year	9,900	18,000	1.40	0.85	0.55
2 Year	4,150	18,000	1.08	0.85	0.23
1 Year	1,110	18,000	0.91	0.85	0.06

*Rainfall amounts shown on Plate 3 reduced by 67 percent for depth area.

The computed runoff amounts developed for Indian Creek, shown in Table 4, were used for basins with drainage areas of 10 square miles or less. For areas between 10 and 240 square miles, the runoff amounts were developed according to the varying design rainfall amounts determined from the area-depth curves shown in Technical Paper No. 40. The generalized existing condition curves were then constructed by applying the computed 1-hour runoff amounts to the unit hydrographs computed for portions of the basin varying in size from 10 to 240 square miles. The existing condition curves are shown on Plates 66 and 67. The residential and commercial development curves were determined by increasing the existing condition runoff amounts according to varying percentages of impervious surface. The estimated

percentages of impervious surface for each land use type were shown on Table 5. The composite runoff amounts for varying degrees of imperviousness were then computed and are shown in Table 8. The estimated residential and commercial development curves are shown on Plates 68 through 71.

b. Unit Hydrograph. An average 1-hour unit hydrograph was derived from streamflow records of five storms at the Mosquito Creek gage location. This unit hydrograph has a peak discharge of 18,000 c.f.s. and Snyder's hydrograph coefficients of C_t = 0.79 and C_p = 0.86. These 1-hour coefficients were used to compute the unit hydrographs for areas within the Mosquito Creek basin varying in size from 10 to 240 square miles.

c. Discharge Probability Analysis. The discharge probability curve for the Mosquito Creek gage location is shown on Plate 72. This curve was developed using the log Pearson Type III distribution with 21 years of stream discharge records. Expected probability and partial duration adjustments were applied to the frequency curve.

5. Application of Generalized Curves. The generalized curves for determining the peak discharge rate and runoff volume are applicable for the following two types of land use conditions: (1) when the study area within the respective Indian Creek or Mosquito Creek basins is 100 percent rural, residential, or commercial; and (2) when the land usage is a combination of two or more of the three land use types. For condition (1), the peak discharge rate and runoff volume versus drainage area may be read directly from the generalized curves. For condition (2), the amounts read for each respective land use should be multiplied by the percent of area for each specific land use to determine the weighted composite discharge rate and runoff volume.

TABLE 8
RUNOFF AMOUNTS FOR VARIOUS FREQUENCY STORMS AND SPECIFIC TYPE LAND USE DEVELOPMENT

Storm Frequency	Existing Condition: Rural 0% Impervious 10 sq.mi. (inches)	Existing Condition: Rural 0% Impervious 240 sq.mi. (inches)	Residential Development: Normal Density 40% Impervious 10 sq.mi. (inches)	Residential Development: Normal Density 40% Impervious 240 sq.mi. (inches)	Commercial Development: Average Density 80% Impervious 10 sq.mi. (inches)	Commercial Development: Average Density 80% Impervious 240 sq.mi. (inches)	Commercial Development: Highly Concentrated 95% Impervious 10 sq.mi. (inches)	Commercial Development: Highly Concentrated 95% Impervious 240 sq.mi. (inches)
100 Year	2.85	2.00	3.11	2.12	3.37	2.24	3.46	2.28
50 Year	2.20	1.49	2.56	1.70	2.92	1.92	3.05	2.00
25 Year	1.70	1.05	2.12	1.35	2.54	1.64	2.69	1.76
10 Year	1.25	0.79	1.69	1.08	2.13	1.38	2.29	1.49
5 Year	0.90	0.55	1.34	0.85	1.78	1.14	1.94	1.25
2 Year	0.42	0.23	0.85	0.52	1.29	0.82	1.46	0.94
1 Year	0.15	0.06	0.59	0.35	1.03	0.64	1.19	0.77

PART IV - "PAPIO" HYDROLOGIC COMPUTER MODEL.

1. General. The "Papio" Hydrologic Computer Model was developed by the Omaha District, Corps of Engineers, to conduct the flood control studies for the Papillion Creek basin. The proposed Corps of Engineers flood control project contains a series of 20 dams and reservoirs within the Papillion Creek basin; the locations are shown on Plate 56. Construction of Dam Sites 11 and 16 have been completed and acquisition of land for future sites is proceeding. The following paragraphs describe the various parameters used in the hydrologic analysis to develop the "Papio" Hydrologic Computer Model.

2. Basin Description.

a. General. Papillion Creek is located in the eastern portion of the State of Nebraska. The basin drainage area is 402 square miles, with a length of about 41 miles and a maximum width of 17 miles. There are three main tributaries that join to form Papillion Creek: Little Papillion Creek, with a drainage area of 62 square miles; Big Papillion Creek, draining 158 square miles; and West Papillion Creek, draining 138 square miles. Topography throughout the basin is moderate to steeply sloping hill land, with small tributary slopes averaging between 50 and 200 feet per mile.

b. Little Papillion Creek. Little Papillion Creek, which drains the eastern portion of the basin, has a length of about 16 miles of which 9 miles lie within the present city limits of Omaha. The 32-square mile area upstream from Irvington is essentially agricultural in character. The remaining 30-square mile area downstream from Irvington is basically a highly developed residential and commercial area. Slopes along the

Little Papillion Creek channel vary from an average of about 20.3 feet per mile upstream from Irvington to an average of about 9.2 feet per mile downstream to the confluence with Big Papillion Creek.

c. Big Papillion Creek. The Big Papillion Creek drains a relatively long, narrow basin. The basin length is about 30 miles and the width varies from 9 miles in the upstream portion to 3 miles in the downstream portion. Most of the area is presently used for agricultural purposes; in the downstream 6 miles, however, a considerable amount of urban development has occurred in recent years. Stream slopes along the Big Papillion Creek channel vary from an average of about 5.3 feet per mile in the upstream portion of the basin to 2.6 feet per mile in the downstream portion.

d. West Papillion Creek. The West Papillion Creek has the most concentrated drainage pattern of the three main tributary streams. The length of this basin is about 20 miles and the maximum width is 11 miles. The basin is extremely hilly and, except for the small communities of Papillion and Millard, is essentially agricultural in character. Stream slopes along the West Papillion Creek vary from an average of about 5.3 feet per mile upstream from Papillion to 4.2 feet per mile downstream to the confluence with Papillion Creek.

3. Unit Hydrographs. The unit hydrographs used were based on an analysis of available flood hydrograph data at the Irvington gaging station. Six floods were analyzed to determine the appropriate unit hydrograph characteristics to apply in other areas of the basin. This analysis indicated that Snyder's constants for a 1-hour unit hydrograph are $C_t = 0.71$ and $C_p = 0.80$. Using

these 1-hour constants, synthetic unit hydrographs were developed for the 46 subarea basins that were used in the hydrologic analysis.

4. Flood Routing Curves. A topographic survey for portions of the Papillion Creek flood plain was made in the spring of 1965. Stage-discharge relationships were computed along each of the three tributary streams (Little Papillion, Big Papillion and West Papillion), in order to develop S+Q/2 routing curves for those reaches of the stream that were surveyed. At those locations in the basin where routing studies were desired but survey data were not available, the routing was accomplished using Tatum's procedure.

5. Hydrologic Analysis. The foregoing paragraphs have described briefly the basic studies made to develop the various parameters used in the hydrologic analysis for the Papillion Creek basin. The Snyder's unit hydrograph constants reflect the runoff characteristics of the basin and permit development of synthetic hydrographs at any point in the basin. The discussion that follows presents the manner in which the hydrologic model was developed in order to determine the existing and future flood conditions throughout the basin and the manner in which the various reservoir schemes were hydrologically evaluated. In general, the procedure that was followed can be described in the following steps:

a. Desired runoff values were applied to the unit hydrographs developed for the 46 subareas in the basin.

b. Beginning at the upper end of each of the three main tributaries, the hydrographs from (a.) were added and routed through the tributary channel and overbank reaches, adding the

inflow from each subarea in the appropriate time relation. This yielded hydrographs at the mouths of the three main tributary streams - Little Papillion, Big Papillion, and West Papillion.

c. The hydrographs from each of the three tributaries determined in (b.) were then added and routed downstream to the upper tieback of the existing Missouri River R-613 Agricultural Levee located at U.S. Highway 73-75.

The computational procedures described were carried out using a Honeywell-GE 437 computer.

6. Hydrograph Reconstitutions. In order to test the above described procedures, two flood events (June 1964 and September 1965) were selected for study; the purpose was to reconstitute the actual hydrographs from these events. The procedure followed in these reconstitutions was as described above, namely, average rainfall values over each of the subarea basins were determined from the isohyetal maps of the storms; runoff values for each subarea were estimated depending on the subarea rainfall and using a consistent loss rate; flood hydrographs for each subarea were computed by applying the estimated runoff values to the unit hydrographs described in paragraph 3; the flood hydrographs were added and routed as described in paragraph 4 and the end product was the development of hydrographs throughout the entire basin. Adjustments in the routing curves were made, where necessary, so that a satisfactory reconstitution of these actual flood events was considered to be an adequate test of the validity of the basic unit hydrographs and routing procedures developed for the basin.

PART V - HYDROLOGIC STUDIES FOR BETZ DRIVE DITCH, BELLEVUE, NEBRASKA

1. General. The results of the hydrology studies for the Flood Hazard Information Report and the Omaha-Council Bluffs Metropolitan Urban Study for Betz Drive Ditch are presented in the following paragraphs.

2. Basin Description. The Betz Drive Ditch is located in Northeastern Bellevue, Nebraska and is a left-bank tributary to Papillion Creek. The total drainage area consists of 1.80 square miles of rapidly urbanizing area with the predominate land use development being residential and commercial. The basin maps with the subbasin breakdowns used in the hydrologic studies are shown on Plates 73 and 74.

3. Flood Hazard Information Report.

a. Discharge Probability. The discharge probability curves that were developed for this study were derived by the Rational Formula and were adjusted for expected probability, based on 48 years of record as indicated in the Weather Bureau publication TP-40. A C value of 0.45 was selected for the 1-percent discharge for each subbasin; this was based, in part, on the basin description previously presented. The C value was reduced for more frequent events. Land slopes range from 2 percent to 10 percent and considerable temporary storage exists above streets and other barriers that cross the channels and impede the flow of runoff. Discharge probability curves are shown on Plate 75. A 1-percent hydrograph was developed for the area upstream from Highway 370 by dividing the 1-percent peak discharge by the unit hydrograph peak discharge and applying the resulting runoff to the unit hydrograph. The hydrograph was routed through the highway

structure (12' x 12' R/C box culvert) by a reservoir routing procedure and this resulted in a 1-percent peak discharge of 1,800 c.f.s.

b. Unit Hydrographs. Unit hydrographs for this study were developed by Snyder's Constants, C_t = 0.39 and C_p = 0.79, which were derived on Indian Creek near Council Bluffs, Iowa and are discussed in Hydrology Design Memorandum No. MIC-1 for Indian Creek Dam dated March 1963. Constants taken from a Big Papillion Creek study were also used to develop unit hydrographs for comparative purposes. The constants developed from the Indian Creek basin were selected for this study because that basin is more representative of the Betz Drive Ditch basin.

c. Standard Project Flood. Standard project flood peak discharges were developed for Betz Drive Ditch at the same locations selected for the discharge probability curves. The criteria presented in EM 1110-2-1411 were used to estimate the standard project rainfall over the basin. A loss rate of 0.30 inch per hour, used in the Big Papillion Creek study, was also used for the Betz Drive Ditch basin. Storm runoff from all areas was increased by 10 percent to reflect the effects of urbanization. The standard project flood has a peak discharge of 3,000 c.f.s. downstream from Highway 370. This discharge was developed by reservoir routing the standard project flood hydrograph, computed for the area upstream of Highway 370, through the 12' x 12' R/C box highway structure.

d. Summary. A summary of the unit hydrograph and the 1-percent and standard project flood peak discharges that are pertinent to Betz Drive Ditch is presented in Table 9.

TABLE 9
SUMMARY OF UNIT HYDROGRAPH, 1-PERCENT FLOOD, AND STANDARD PROJECT FLOOD PEAK DISCHARGES

Location	Area	Drainage Area	Unit Graph Peak (c.f.s.)	1-Percent Peak (c.f.s.)	SPF Peak (c.f.s.)
At Papillion Cr.	1	1.80	(Use discharges of Area 2)		
Below Hwy 370	2	1.67	-	1,800	3,000
Above Hwy 370	2A	1.67	1,780	2,680	6,100
Below Junct. @ Lloyd St.	3	1.21	1,860	2,400	5,000
Above Junct. @ Lloyd St.	3A	0.82	1,150	1,600	3,800
Below Junct. @ Lincoln Rd.	4	0.45	1,000	1,370	3,000
S. Branch Above Lincoln Rd.	5	0.27	570	800	1,800
N. Branch Above Lincoln Rd.	6	0.18	400	570	1,200

4. Omaha-Council Bluffs Metropolitan Urban Study. The Betz Drive Ditch hydrology was restudied in order to develop a hydrologic model of the basin that would be capable of determining the affects that future urbanization might have on the peak discharge rates for the 1-percent and standard project floods. The Environmental Protection Agency Stormwater Management Model was used to compute the design runoff hydrographs. This surface runoff model is a detailed, mathematical computer model that calculates the amount and distribution of runoff from a storm; it uses the basic basin parameters such as size, slope, soil loss rates, type of land surface cover, and hydraulic characteristics of the conveyance facilities. The Betz Drive Ditch basin was divided into 14 subbasins, 7 channels, and 1 culvert-reservoir routing located at the Highway 370 crossing. The

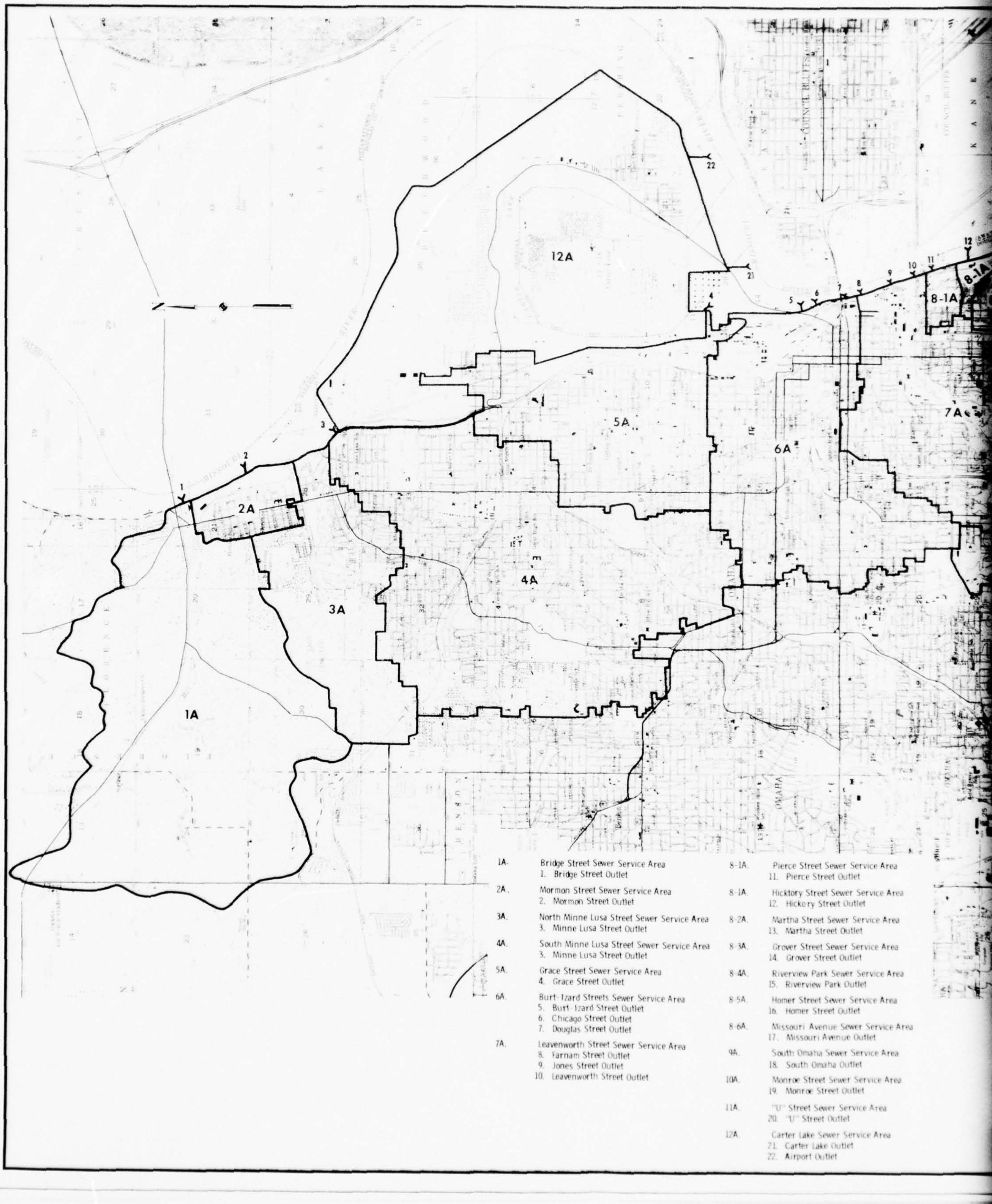
subbasin breakdown is shown on Plate 74. Using 1973 land use conditions, which were determined from aerial photographs, the average amount of impervious area was computed for each of the subbasins. The average percent of impervious area for each of the 14 subbasins is presented in Table 10. Using the 1973 land use conditions, the 1 percent and standard project flood peak discharges were determined for various locations within the Betz Drive Ditch basin. These peak discharges are summarized in Table 11.

TABLE 10
AVERAGE PERCENT OF IMPERVIOUS AREA
FOR EACH BETZ DRIVE DITCH SUBBASIN
ACCORDING TO 1973 LAND USE CONDITIONS

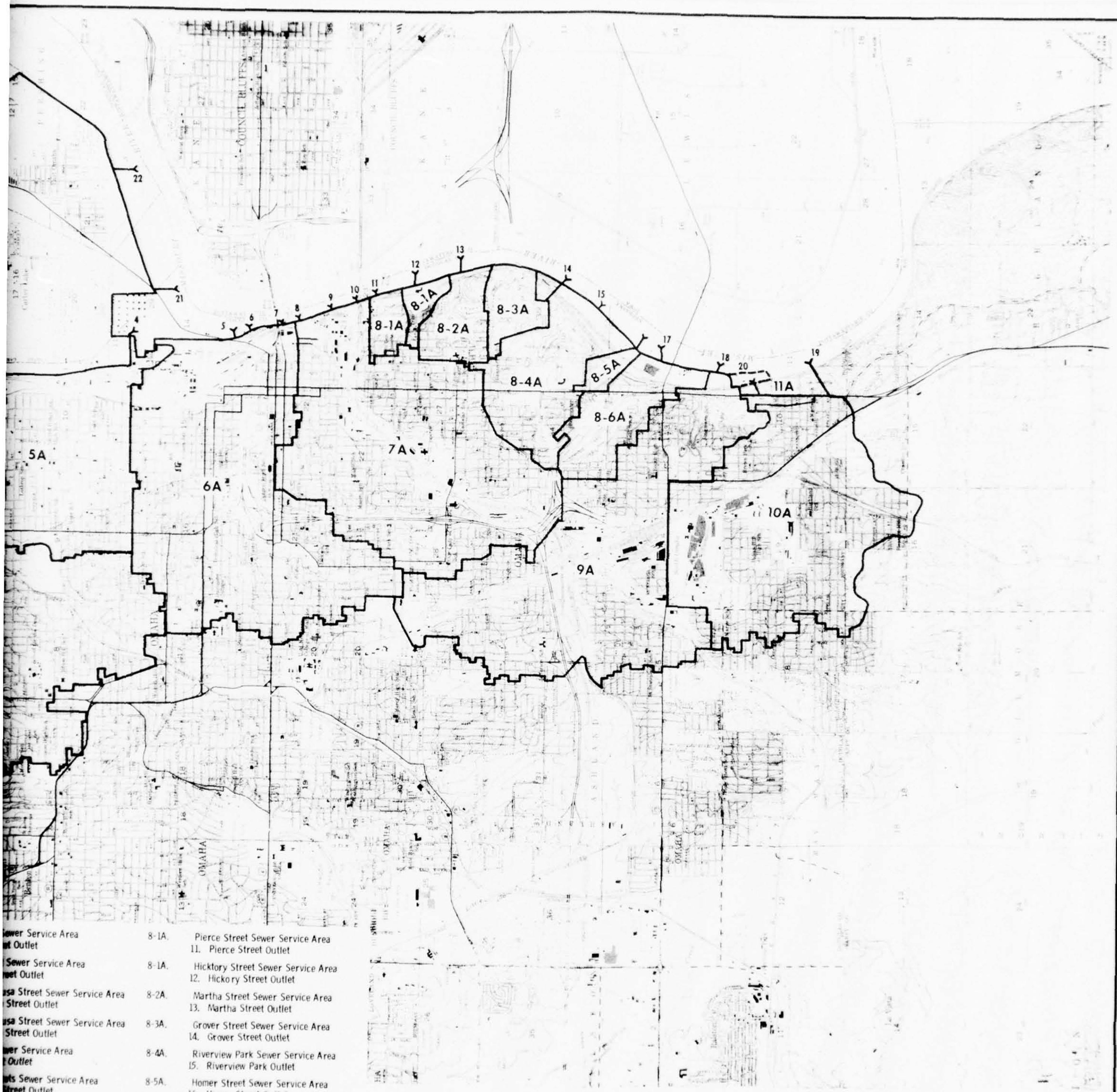
Subbasin No.	Average Percent of Impervious Area
1	24
2	25
3	24
4	24
5	37
6	22
7	23
8	25
9	20
10	27
11	24
12	25
13	8
14	19

TABLE 11
SUMMARY OF 1 PERCENT FLOOD
AND STANDARD PROJECT FLOOD PEAK DISCHARGES

Location	Drainage Area (sq.mi.)	1 Percent Peak (c.f.s.)	SPF Peak (c.f.s.)
At Papillion Creek	1.80	2,639	3,534
Below Highway 370	1.67	2,447	3,260
Above Highway 370	1.67	3,225	6,454
Below Junct. @ Lloyd St.	1.21	2,486	4,657
Above Junct. @ Lloyd St.	0.82	1,688	3,240
Below Junct. @ Lincoln St.	0.45	1,370	2,359
S. Branch Above Lincoln Rd.	0.27	770	1,291
N. Branch Above Lincoln Rd.	0.18	599	1,049



COUNCIL BLUFFS
KANE
12A
1A
2A
3A
4A
5A
6A
7A
8-1A
OMAHA
1A. Bridge Street Sewer Service Area
1. Bridge Street Outlet
2A. Mormon Street Sewer Service Area
2. Mormon Street Outlet
3A. North Minne Lusa Street Sewer Service Area
3. Minne Lusa Street Outlet
4A. South Minne Lusa Street Sewer Service Area
3. Minne Lusa Street Outlet
5A. Grace Street Sewer Service Area
4. Grace Street Outlet
6A. Burt-Izard Streets Sewer Service Area
5. Burt-Izard Street Outlet
6. Chicago Street Outlet
7. Douglas Street Outlet
7A. Leavenworth Street Sewer Service Area
8. Farnam Street Outlet
9. Jones Street Outlet
10. Leavenworth Street Outlet
8-1A. Pierce Street Sewer Service Area
11. Pierce Street Outlet
8-1A. Hicktory Street Sewer Service Area
12. Hickory Street Outlet
8-2A. Martha Street Sewer Service Area
13. Martha Street Outlet
8-3A. Grover Street Sewer Service Area
14. Grover Street Outlet
8-4A. Riverview Park Sewer Service Area
15. Riverview Park Outlet
8-5A. Homer Street Sewer Service Area
16. Homer Street Outlet
8-6A. Missouri Avenue Sewer Service Area
17. Missouri Avenue Outlet
9A. South Omaha Sewer Service Area
18. South Omaha Outlet
10A. Monroe Street Sewer Service Area
19. Monroe Street Outlet
11A. "U" Street Sewer Service Area
20. "U" Street Outlet
12A. Carter Lake Sewer Service Area
21. Carter Lake Outlet
22. Airport Outlet



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8-1A. Pierce Street Sewer Service Area
11. Pierce Street Outlet

8-1A. Hickory Street Sewer Service Area
12. Hickory Street Outlet

8-2A. Martha Street Sewer Service Area
13. Martha Street Outlet

8-3A. Grover Street Sewer Service Area
14. Grover Street Outlet

8-4A. Riverview Park Sewer Service Area
15. Riverview Park Outlet

8-5A. Homer Street Sewer Service Area
16. Homer Street Outlet

8-6A. Missouri Avenue Sewer Service Area
17. Missouri Avenue Outlet

9A. South Omaha Sewer Service Area
18. South Omaha Outlet

10A. Monroe Street Sewer Service Area
19. Monroe Street Outlet

11A. "U" Street Sewer Service Area
20. "U" Street Outlet

12A. Carter Lake Sewer Service Area
21. Carter Lake Outlet
22. Airport Outlet

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
OMAHA–MISSOURI RIVER
SEWER SERVICE AREA BASIN MAP
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

VOLUME V ANNEX C PLATE I

DRAINAGE BASINS		HYDROLOGIC CHARACTERISTICS OF THE BASINS									25 Ye	
Sewer Service Areas												
No.	Designation	Drainage Area Size (Acres)	Max Flow Distance (Feet)	Area Pervious (Percent)	Area Impervious (Percent)	$C_{per.}$ @ 100 Year	$C_{imp.}$ @ All Frequencies	$C_{comp.}$ @ 100 Year	TC (Hours)	Fav. (Inches)	Peak Q (C.F.S.)	Max 1-Hr Volume (Ac-Ft)
1A	Bridge St. Area	3,914	21,965	70	30	0.25	1.00	0.48	1.00	0.10	4,133	344.2
2A	Mormon St. Area	316	3,590	72	28	0.20	1.00	0.42	0.25	0.10	670	24.6
3A	North Minne Lusa St.	1,365	14,500	56	44	0.25	1.00	0.58	1.00	0.10	1,802	150.1
4A	South Minne Lusa St.	3,995	21,000	47	53	0.25	1.00	0.65	1.00	0.10	5,945	495.1
5A	Grace St. Area	1,680	15,600	39	61	0.25	1.00	0.71	1.00	0.10	2,782	231.7
6A	Burt-Izard St. Area	2,268	16,000	29	71	0.30	1.00	0.80	1.00	0.10	4,245	353.6
7A	Leavenworth St. Area	2,061	15,200	34	66	0.25	1.00	0.75	1.00	0.10	3,610	300.7
8-1A	Pierce St. Area	100	2,800	53	47	0.35	1.00	0.66	0.25	0.10	337	12.4
	Hickory St. Area	74	2,600	57	43	0.35	1.00	0.63	0.25	0.10	238	8.7
8-2A	Martha St. Area	212	4,000	71	29	0.35	1.00	0.54	0.25	0.10	554	20.3
8-3A	Grover St. Area	150	3,200	77	23	0.35	1.00	0.50	0.25	0.10	359	13.2
8-4A	Riverview Park Area	632	7,600	68	32	0.25	1.00	0.49	0.50	0.10	1,051	55.6
8-5A	Homer St. Area	65	2,800	59	41	0.35	1.00	0.62	0.25	0.10	202	7.4
8-6A	Missouri Ave. Area	386	7,000	70	30	0.25	1.00	0.48	0.50	0.10	642	34.0
9A	South Omaha Area	2,116	18,400	49	51	0.20	1.00	0.61	1.00	0.10	2,996	249.5
10A	Monroe St. Area	1,760	13,000	42	58	0.20	1.00	0.67	1.00	0.10	2,746	228.7
11A	"U" St. Area	33	2,000	49	51	0.25	1.00	0.63	0.25	0.10	110	4.0
12A	Carter Lake Area	4,165	--	74	26	0.10	1.00	0.33	--	0.20	--	295.0

OMAHA-MISSOURI RIVER URBAN STUDY
OMAHA-MISSOURI RIVER TREATMENT PLANT SEWER SERVICE AREA
(EXISTING DEVELOPMENT CONDITIONS)

HYDROLOGIC DESIGN PEAK DISCHARGES AND VOLUMES FOR SELECTED FREQUENCY STORM EVENTS

25 Year Storm				10 Year Storm				5 Year Storm				2 Year Storm			
Peak Q (C.F.S.)	Max 1-Hr Volume (Ac-Ft)	Max 6-Hr Volume (Ac-Ft)	Max 24-Hr Volume (Ac-Ft)	Peak Q (C.F.S.)	Max 1-Hr Volume (Ac-Ft)	Max 6-Hr Volume (Ac-Ft)	Max 24-Hr Volume (Ac-Ft)	Peak Q (C.F.S.)	Max 1-Hr Volume (Ac-Ft)	Max 6-Hr Volume (Ac-Ft)	Max 24-Hr Volume (Ac-Ft)	Peak Q (C.F.S.)	Max 1-Hr Volume (Ac-Ft)	Max 6-Hr Volume (Ac-Ft)	Max 2 Vol (Ac-F
4,133	344.2	515.1	711.3	3,402	283.3	428.7	590.0	2,771	230.8	350.8	481.2	2,076	172.8	258.2	358.6
670	24.6	36.8	50.8	562	20.8	31.3	43.1	455	16.8	25.5	35.0	341	12.6	18.7	26.0
1,802	150.1	224.5	310.1	1,498	124.7	188.6	259.7	1,256	104.6	159.0	218.2	947	78.9	117.7	163.5
5,945	495.1	740.6	1,023.0	5,045	420.2	635.1	874.7	4,243	353.3	537.0	736.6	3,206	266.8	398.6	553.6
2,782	231.7	346.6	478.8	2,365	197.0	297.7	410.1	1,992	165.9	252.1	345.9	1,508	125.6	187.5	260.4
4,245	353.6	528.9	730.8	3,615	301.1	455.2	626.9	3,051	254.1	386.1	529.7	2,313	192.7	287.7	399.5
3,610	300.7	449.8	621.5	3,072	255.7	386.8	532.6	2,590	215.7	327.8	449.7	1,962	163.4	243.9	338.8
337	12.4	18.5	25.6	276	10.1	15.4	21.2	232	8.6	13.0	17.8	172	3.6	9.5	13.2
238	8.7	13.1	18.0	194	7.1	10.8	14.9	163	6.0	9.1	12.5	121	4.4	6.2	9.2
554	20.3	30.4	42.0	446	16.4	24.9	34.3	365	13.4	20.4	28.0	268	9.8	14.7	20.4
359	13.2	19.7	27.3	288	10.6	16.0	22.1	234	8.6	13.1	18.0	166	6.1	9.1	12.7
1,051	55.6	83.2	114.8	866	45.[illegible]	69.3	95.4	722	38.3	58.2	79.8	529	28.0	41.8	58.1
202	7.4	11.1	15.4	167	6.2	9.3	12.8	136	5.1	7.7	10.6	102	3.8	5.6	7.8
642	34.0	52.2	70.1	528	28.0	42.3	58.2	429	22.8	34.6	47.5	314	13.1	24.8	34.5
2,996	249.5	373.2	515.6	2,540	211.6	319.8	440.5	2,135	177.8	270.1	370.6	1,612	134.3	203.8	283.2
2,746	228.7	342.1	472.6	2,332	194.2	293.6	404.2	1,963	163.4	248.4	340.8	1,484	123.6	184.5	256.2
110	4.0	6.0	8.3	91	3.4	5.1	7.0	77	2.8	4.3	5.9	58	2.1	3.1	4.4
--	295.0	430.0	565.0	--	244.0	362.0	471.0	--	199.0	299.0	392.0	--	148.0	224.0	298.0

ICE AREA

HYDROLOGIC DESIGN PEAK DISCHARGES AND VOLUMES FOR SELECTED FREQUENCY STORM EVENTS

Year Storm			5 Year Storm				2 Year Storm				1 Year Storm			
-Hr me t)	Max 6-Hr Volume (Ac-Ft)	Max 24-Hr Volume (Ac-Ft)	Peak Q (C.F.S.)	Max 1-Hr Volume (Ac-Ft)	Max 6-Hr Volume (Ac-Ft)	Max 24-Hr Volume (Ac-Ft)	Peak Q (C.F.S.)	Max 1-Hr Volume (Ac-Ft)	Max 6-Hr Volume (Ac-Ft)	Max 24-Hr Volume (Ac-Ft)	Peak Q (C.F.S.)	Max 1-Hr Volume (Ac-Ft)	Max 6-Hr Volume (Ac-Ft)	Max 24-Hr Volume (Ac-Ft)
3	428.7	590.0	2,771	230.8	350.8	481.2	2,076	172.8	258.2	358.6	1,681	139.8	203.1	286.2
8	31.3	43.1	455	16.8	25.5	35.0	341	12.6	18.7	26.0	275	5.7	14.7	20.7
7	188.6	259.7	1,256	104.6	159.0	218.2	947	78.9	117.7	163.5	771	64.2	93.2	131.3
2	635.1	874.7	4,243	353.3	537.0	736.6	3,206	266.8	398.6	553.6	2,618	217.9	316.4	445.8
0	297.7	410.1	1,992	165.9	252.1	345.9	1,508	125.6	187.5	260.4	1,234	102.8	149.2	210.2
1	455.2	626.9	3,051	254.1	386.1	529.7	2,313	192.7	287.7	399.5	1,897	157.9	229.3	322.8
7	386.8	532.6	2,590	215.7	327.8	449.7	1,962	163.4	243.9	338.8	1,606	133.9	182.4	273.6
1	15.4	21.2	232	8.6	13.0	17.8	172	3.6	9.5	13.2	141	5.2	7.5	10.6
1	10.8	14.9	163	6.0	9.1	12.5	121	4.4	6.2	9.2	99	3.6	5.3	7.4
[illegible]	24.9	34.3	365	13.4	20.4	28.0	268	9.8	14.7	20.4	217	8.0	11.6	16.3
[illegible]	16.0	22.1	234	8.6	13.1	18.0	166	6.1	9.1	12.7	134	4.9	7.2	10.1
[illegible]	69.3	95.4	722	38.3	58.2	79.8	529	28.0	41.8	58.1	429	22.7	32.9	46.4
[illegible]	9.3	12.8	138	5.1	7.7	10.6	102	3.8	5.6	7.8	83	3.1	4.4	6.2
[illegible]	42.3	58.2	429	22.8	34.6	47.5	314	13.1	24.8	34.5	254	13.4	19.5	27.5
[illegible]	319.8	440.5	2,135	177.8	270.1	370.6	1,612	134.3	203.8	283.2	1,316	109.6	158.9	224.0
[illegible]	293.6	404.2	1,963	163.4	248.4	340.8	1,484	123.6	184.5	256.2	1,213	117.1	146.6	206.5
[illegible]	5.1	7.0	77	2.8	4.3	5.9	58	2.1	3.1	4.4	47	1.7	2.5	3.6
[illegible]	362.0	471.0	--	199.0	299.0	392.0	--	148.0	224.0	298.0	--	115.0	173.0	232.0

TABULATION OF DATA CORRESPONDING TO ENVELOPING CURVES OF ACCUMULATIVE RAINFALL-DURATION-FREQUENCY RELATIONS

Line Ref.	Maximum Rainfall Duration In Hours	(1) RAINFALL IN INCHES DEPTH CORRESPONDING TO VARIOUS AVERAGE FREQUENCIES AND DURATIONS IN HOURS — Average Exceedence Frequency Interval, in Years						
		1	2	5	10	25	50	100
Col. 1	2	3	4	5	6	7	8	9
(a)	Maximum Accumulation of Rainfall in Period Designated Column 2							
	0.25	0.76	0.91	1.19	1.40	1.62	1.82	2.04
	0.50	1.06	1.27	1.66	1.95	2.25	2.53	2.84
1	1	1.35	1.62	2.11	2.47	2.86	3.21	3.60
2	2	1.55	1.86	2.45	2.84	3.30	3.70	4.15
3	3	1.68	2.04	2.64	3.07	3.54	3.97	4.46
4	4	1.77	2.16	2.78	3.24	3.72	4.20	4.76
5	5	1.85	2.26	2.94	3.40	3.90	4.40	4.98
6	6	1.92	2.35	3.07	3.55	4.06	4.56	5.15
7	12							
8	18							
9	24	2.52	3.05	3.95	4.60	5.02	5.98	6.67
10	48							
11	72							
12	96							
(b)	Rainfall by 1-Hour Increments During Maximum 6-Hour Accumulation							
13	0-1	1.35	1.62	2.11	2.47	2.86	3.21	3.60
14	1-2	0.20	0.24	0.34	0.37	0.44	0.49	0.55
15	2-3	0.13	0.18	0.19	0.23	0.24	0.27	0.31
16	3-4	0.09	0.12	0.14	0.17	0.18	0.23	0.30
17	4-5	0.08	0.10	0.16	0.16	0.18	0.20	0.22
18	5-6	0.07	0.09	0.13	0.15	0.16	0.16	0.17
(c)	Rainfall by 6-Hour Increments During Maximum 24-Hour Accumulation							
19	0-6	1.92	2.35	3.07	3.55	4.06	4.56	5.15
20	6-12							
21	12-18							
22	18-24							
(d)	Rainfall by 24-Hour Increments During Maximum 96-Hour Accumulation							
23	0-24	2.52	3.05	3.95	4.60	5.28	5.98	6.67
24	24-48							
25	48-72							
26	72-96							

(1) Point rainfall values for Omaha, Nebraska. Reference: U.S. Weather Bureau Technical Paper No. 40.

TABULATION OF DATA CORRESPONDING TO ENVELOPING CURVES
OF ACCUMULATIVE RAINFALL-DURATION-FREQUENCY RELATIONS

Line Ref.	Maximum Rainfall Duration In Hours	(1) RAINFALL IN INCHES DEPTH CORRESPONDING TO VARIOUS AVERAGE FREQUENCIES AND DURATIONS IN HOURS						
		Average Exceedence Frequency Interval, in Years						
		1	2	5	10	25	50	100
Col. 1	2	3	4	5	6	7	8	9
(a)	Maximum Accumulation of Rainfall in Period Designated Column 2							
	0.25	0.64	0.77	1.00	1.17	1.36	1.52	1.71
	0.50	0.89	1.07	1.39	1.63	1.89	2.12	2.38
1	1	1.13	1.36	1.77	2.07	2.40	2.69	3.02
2	2	1.37	1.65	2.15	2.52	2.93	3.29	3.69
3	3	1.49	1.81	2.34	2.73	3.15	3.55	3.96
4	4	1.59	1.94	2.52	2.91	3.35	3.78	4.22
5	5	1.68	2.05	2.67	3.09	3.54	3.99	4.48
6	6	1.74	2.13	2.79	3.23	3.69	4.14	4.68
7	12							
8	18							
9	24	2.41	2.92	3.79	4.41	5.06	5.74	6.40
10	48							
11	72							
12	96							
(b)	Rainfall by 1-Hour Increments During Maximum 6-Hour Accumulation							
13	0-1	1.13	1.36	1.77	2.07	2.40	2.69	3.02
14	1-2	0.24	0.29	0.38	0.45	0.53	0.60	0.61
15	2-3	0.12	0.16	0.19	0.21	0.22	0.26	0.27
16	3-4	0.10	0.13	0.18	0.18	0.20	0.23	0.26
17	4-5	0.09	0.11	0.15	0.18	0.19	0.21	0.26
18	5-6	0.06	0.08	0.12	0.14	0.15	0.15	0.20
(c)	Rainfall by 6-Hour Increments During Maximum 24-Hour Accumulation							
19	0-6	1.74	2.13	2.79	3.23	3.69	4.14	4.68
20	6-12							
21	12-18							
22	18-24							
(d)	Rainfall by 24-Hour Increments During Maximum 96-Hour Accumulation							
23	0-24	2.41	2.92	3.79	4.41	5.06	5.74	6.40
24	24-48							
25	48-72							
26	72-96							

(1) Average rainfall amounts for a 33-square mile area at Omaha, Nebraska. Reference U.S. Weather Bureau Technical Paper No. 40.

RUNOFF COEFFICIENTS (C_{100})

OPEN AND PARK AREA

1.	Sandy soil, flat, <2%	(100% Pervious)	C_{100}	= 0.10 - 0.15
2.	Sandy soil, ave., 2-7%	(100% Pervious)	C_{100}	= 0.15 - 0.20
3.	Sandy soil, steep, >7%	(100% Pervious)	C_{100}	= 0.20 - 0.30
4.	Heavy soil, flat, <2%	(100% Pervious)	C_{100}	= 0.15 - 0.25
5.	Heavy soil, ave., 2-7%	(100% Pervious)	C_{100}	= 0.25 - 0.35
6.	Heavy soil, steep, >7%	(100% Pervious)	C_{100}	= 0.35 - 0.45

RESIDENTIAL DEVELOPMENT

7.	Large Lot	(30% Impervious, 70% Pervious; C_{imp} = 1.0 C_{per} = 0.10 - 0.45)	C_{100}	= 0.37 - 0.61
8.	Normal	(40% Impervious, 60% Pervious; C_{imp} = 1.0 C_{per} = 0.10 - 0.45)	C_{100}	= 0.46 - 0.67
9.	Dense	(55% Impervious, 45% Pervious; C_{imp} = 1.0 C_{per} = 0.10 - 0.45)	C_{100}	= 0.60 - 0.75

COMMERCIAL AND INDUSTRIAL DEVELOPMENT

10.	Normal	(80% Impervious, 20% Pervious; C_{imp} = 1.0 C_{per} = 0.10 - 0.45)	C_{100}	= 0.82 - 0.89
11.	Concentrated	(95% Impervious, 5% Pervious; C_{imp} = 1.0 C_{per} = 0.10 - 0.45)	C_{100}	= 0.95 - 0.97
12.	Impervious Surface	(100% Impervious)	C_{100}	= 1.00

Bernard's Equation: $C_F = C_{100} \left(\frac{F}{100} \right)^x$ for pervious areas.

x = 0.18 for Omaha, Nebraska

C_{100} = 1.00 x C_{100}

C_{50} = 0.88 x C_{100}

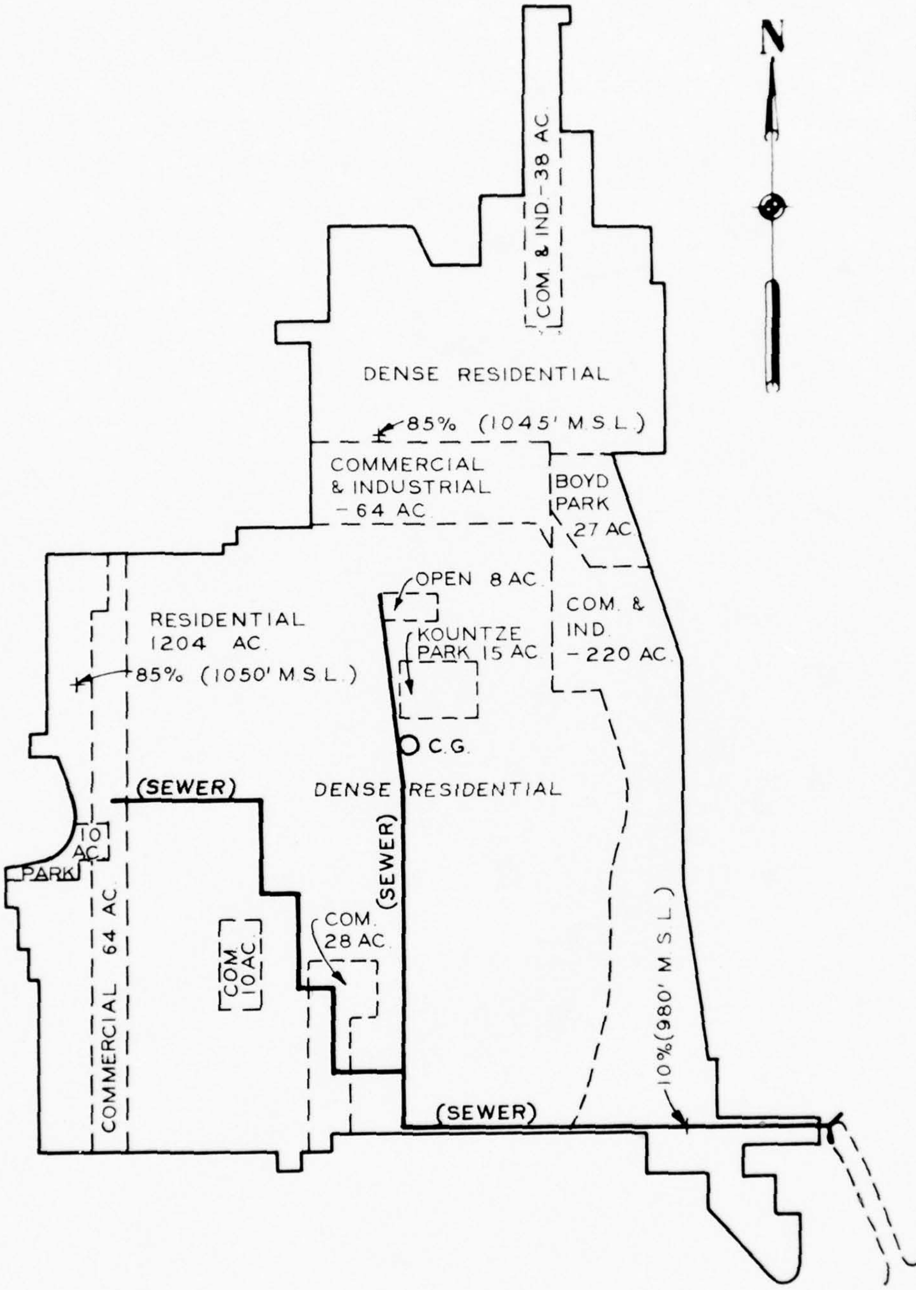
C_{25} = 0.78 x C_{100}

C_{10} = 0.66 x C_{100}

C_5 = 0.58 x C_{100}

C_2 = 0.49 x C_{100}

C_1 = 0.44 x C_{100}



TOTAL AREA - 1,680 ac

COMMERICAL & IND.	-	424 ac.
OPEN OR PARK	-	60 ac.
RESIDENTIAL		1,196 ac.

L = 15,600 feet

10% L = 1,560 = 980.0' m.s.l.

85% L = 13,260 = 1,050.0' m.s.l.

$$\text{Slope}_{\text{index}} = \frac{1{,}050.0 - 980.0}{13{,}260.0 - 1{,}560.0} = 0.$$

"C" value determination

Total Area Impervious

10. Commercial = 80% x 220 ac. =
11. Commerical = 95% x 204 ac. =
9. Residential = 55% x1,196 ac. =

$\frac{1028}{1680}$ = 61% impervious

Total Area Pervious

4. Open or Park = =
9. Residential = 45% x 1,196 =
10. Commercial = 20% x 220 =
11. Commerical = 5% x 204 =

$\frac{652}{1,680}$ = 39% Pervious

l,680 ac

). - 424 ac.
- 60 ac.
1,196 ac.

feet
= 980.0' m.s.l.
= 1,050.0' m.s.l.

$\frac{1{,}050.0 - 980.0}{3{,}260.0 - 1{,}560.0} = 0.6\%$

determination

rvious

=	80% x 220 ac.	=	176 ac.
=	95% x 204 ac.	=	194 ac.
=	55% x1,196 ac.	=	658 ac.
			1,028 ac.

impervious

ious

rk =		=	60 ac.
l =	45% x 1,196	=	538 ac.
=	20% x 220	=	44 ac.
=	5% x 204	=	10 ac.
			652 ac.

Pervious

"C" value determination:

C_{25}	=	$C_{per(4)}$	=	0.25(.39).78	=	0.08	C_{25} = 0.69
		$C_{imp(12)}$	=	.00(.61)	=	0.61	
C_{10}	=	$C_{per(4)}$	=	0.25(.39).66	=	0.07	C_{10} = 0.68
		$C_{imp(12)}$	=	1.00(.61)	=	0.61	
C_5	=	$C_{per(4)}$	=	0.25(.39).58	=	0.06	C_5 = 0.67
		$C_{imp(12)}$	=	1.00(.61)	=	0.61	
C_2	=	$C_{per(4)}$	=	0.25(.39).49	=	0.05	C_2 = 0.66
		$C_{imp(12)}$	=	1.00(.61)	=	0.61	
C_1	=	$C_{per(4)}$	=	0.25(.39).44	=	0.04	C_1 = 0.65
		$C_{imp(12)}$	=	1.00(.61)	=	0.61	

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

5A

GRACE STREET SEWER SERVICE AREA
DRAINAGE BASIN

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

OMAHA MISSOURI RIVER URBAN STUDY
5A GRACE STREET SEWER SERVICE AREA
MAXIMUM 6 HOUR AND 24 HOUR VOLUMES

D.A. - 1,680 acres
Tc - 60 min.
Fav - 0.10 inches

39% of the area is pervious C_{100} = 0.25)
61% of the area is impervious C_{100} = 1.00) C_{100}= 0.71

MAXIMUM 6 HOUR VOLUMES

25 yr. rain = 3.69 in						
VOL_{25} = (3.69-0.10).69	=	2.477	in	=	346.6	ac-ft
10 yr. rain = 3.23 in						
VOL_{10} = (3.23-0.10).68	=	2.128	in	=	297.7	ac-ft
5 yr. rain = 2.79 in						
VOL_{5} = (2.79-0.10).67	=	1.802	in	=	252.1	ac-ft
2 yr. rain = 2.13 in						
VOL_{2} = (2.13-0.10).66	=	1.340	in	=	187.5	ac-ft
1 yr. rain = 1.74 in						
VOL_{1} = (1.74-0.10).65	=	1.066	in	=	149.2	ac-ft

MAXIMUM 24 HOUR VOLUMES

25 yr. rain = 5.06 in						
VOL_{25} = (5.06-0.10).69	=	3.422	in	=	478.8	ac-ft
10 yr. rain = 4.41 in						
VOL_{10} = (4.41-0.10).68	=	2.931	in	=	410.1	ac-ft
5 yr. rain = 3.79 in						
VOL_{5} = (3.79-0.10).67	=	2.472	in	=	345.9	ac-ft
2 yr. rain = 2.92 in						
VOL_{2} = (2.92-0.10).66	=	1.861	in	=	260.4	ac-ft
1 yr. rain = 2.41 in						
VOL_{1} = (2.41-0.10).65	=	1.502	in	=	210.2	ac-ft

OMAHA MISSOURI RIVER URBAN STUDY
5A GRACE STREET SEWER SERVICE AREA
25-10-5-2-1 YEAR STORM HYDROGRAPHS

6th Hour

25 yr rain = 2.40 in. I = 2.40 in/hr. T_c = 60 min F_{av} = 0
Q_{25} = 0.69 (2.40-0)1,680 = 2,782 c.f.s.
VOL_{25} = 231.7 ac-ft. $Runoff_{25}$ = 1.656 in.

10 yr rain = 2.07 in. I = 2.07 in/hr.
Q_{10} = 0.68 (2.07-0) 1,680 = 2,365 c.f.s.
VOL_{10} = 197.0 ac-ft. $Runoff_{10}$ = 1.408 in.

5 yr rain = 1.77 in. I = 1.77 in/hr.
Q_5 = 0.67 (1.77-0) 1,680 = 1,992 c.f.s.
VOL_5 = 165.9 ac-ft. $Runoff_5$ = 1.186 in.

2 yr rain = 1.36 in. I = 1.36 in/hr.
Q_2 = 0.66 (1.36-0) 1,680 = 1,508 c.f.s.
VOL_2 = 125.6 ac-ft. $Runoff_2$ = 0.898 in.

1 yr rain = 1.13 in. I = 1.13 in/hr.
Q_1 = 0.65 (1.13-0) 1,680 = 1,234 c.f.s.
VOL_1 = 102.8 ac-ft. $Runoff_1$ = 0.735 in.

5th Hour

25 yr rain = 0.53 in. I = 0.53 in/hr. T_c = 60 min F_{av} = 0
Q_{25} = 0.69 (0.53-0) 1,680 = 614 c.f.s.
VOL_{25} = 51.2 ac-ft. $Runoff_{25}$ = 0.366 in.

10 yr rain = 0.45 in. I = 0.45 in/hr.
Q_{10} = 0.68 (0.45-0) 1,680 = 514 c.f.s.
VOL_{10} = 42.8 ac-ft. $Runoff_{10}$ = 0.306 in.

5 yr rain = 0.38 in. I = 0.38 in/hr.
Q_5 = 0.67 (0.38-0) 1,680 = 428 c.f.s.
VOL_5 = 35.7 ac-ft. $Runoff_5$ = 0.255 in.

2 yr rain = 0.29 in. I = 0.29 in/hr.
Q_2 = 0.66 (0.29-0) 1,680 = 322 c.f.s.
VOL_2 = 26.7 ac-ft. $Runoff_2$ = 0.191 in.

1 yr rain = 0.24 in. I = 0.24 in/hr.
Q_1 = 0.65 (0.24-0) 1,680 = 262 c.f.s.
VOL_1 = 21.8 ac-ft. $Runoff_1$ = 0.156 in.

OMAHA MISSOURI RIVER URBAN STUDY
5A GRACE STREET SEWER SERVICE AREA
25-10-5-2-1 YEAR STORM HYDROGRAPHS (CONT.)

4th Hour

25 yr rain = 0.22 in. I = 0.22 in/hr. T_c = 60 min F_{av} = 0
Q_{25} = 0.69 (0.22-0) 1,680 = 255 c.f.s.
VOL_{25} = 21.3 ac-ft. $Runoff_{25}$ = 0.152 in.

10 yr rain = 0.21 in. I = 0.21 in/hr.
Q_{10} = 0.68 (0.21-0) 1,680 = 240 c.f.s.
VOL_{10} = 20.0 ac-ft. $Runoff_{10}$ = 0.143 in.

5 yr rain = 0.19 in. I = 0.19 in/hr.
Q_5 = 0.67 (0.19-0) 1,680 = 214 c.f.s.
VOL_5 = 17.7 ac-ft. $Runoff_5$ = 0.127 in.

2 yr rain = 0.16 in. I = 0.16 in/hr.
Q_2 = 0.66 (0.16-0) 1,680 = 177 c.f.s.
VOL_2 = 14.8 ac-ft. $Runoff_2$ = 0.106 in.

1 yr rain = 0.12 in. I = 0.12 in/hr.
Q = 0.65 (0.12-0) 1,680 = 131 c.f.s.
VOL_1 = 10.9 ac-ft. $Runoff_1$ = 0.078 in.

3rd Hour

25 yr rain = 0.20 in. I = 0.20 in/hr. T_c = 60 min F_{av} = 0
Q_{25} = 0.69 (0.20-0) 1,680 = 232 c.f.s.
VOL_{25} = 19.3 ac-ft. $Runoff_{25}$ = 0.138 in.

10 yr rain = 0.18 in. I = 0.18 in/hr.
Q_{10} = 0.68 (0.18-0) 1,680 = 206 c.f.s.
VOL_{10} = 17.1 ac-ft. $Runoff_{10}$ = 0.122 in.

5 yr rain = 0.18 in. I = 0.18 in/hr.
Q_5 = 0.67 (0.18-0) 1,680 = 203 c.f.s.
VOL_5 = 16.9 ac-ft. $Runoff_5$ = 0.121 in.

2 yr rain = 0.13 in. I = 0.13 in/hr.
Q_2 = 0.66 (0.13-0) 1,680 = 144 c.f.s.
VOL_2 = 12.0 ac-ft. Runoff = 0.086 in.

1 yr rain = 0.10 in. I = 0.10 in/hr.
Q_1 = 0.65 (0.10-0) 1,680 = 109 c.f.s.
VOL_1 = 9.1 ac-ft. $Runoff_1$ = 0.065 in.

OMAHA MISSOURI RIVER URBAN STUDY
5A GRACE STREET SEWER SERVICE AREA
25-10-5-2-1 YEAR STORM HYDROGRAPHS (CONT.)

2nd Hour

25 yr rain = 0.19 in. I = 0.19 in/hr. T_c = 60 min F_{av} = 0
Q_{25} = 0.69 (0.19-0) 1,680 = 220 c.f.s.
VOL_{25} = 18.3 ac-ft. $Runoff_{25}$ = 0.131 in.

10 yr rain = 0.18 in. I = 0.18 in/hr.
Q_{10} = 0.68 (0.18-0) 1,680 = 206 c.f.s.
VOL_{10} = 17.1 ac-ft. $Runoff_{10}$ = 0.122 in.

5 yr rain = 0.15 in. I = 0.15 in/hr.
Q_5 = 0.67 (0.15-0) 1,680 = 169 c.f.s.
VOL_5 = 14.1 ac-ft. $Runoff_5$ = 0.101 in.

2 yr rain = 0.11 in. I = 0.11 in/hr. F_{av} = 0.02 in/hr.
Q_2 = 0.66 (0.11-0.02) 1,680 = 100 c.f.s.
VOL_2 = 8.3 ac-ft. $Runoff_2$ = 0.059 in.

1 yr rain = 0.09 in. I = 0.09 in/hr. F_{av} = 0.04 in/hr.
Q_1 = 0.65 (0.09-0.04) 1,680 = 55 c.f.s.
VOL_1 = 4.6 ac-ft. $Runoff_1$ = 0.033 in.

1st Hour

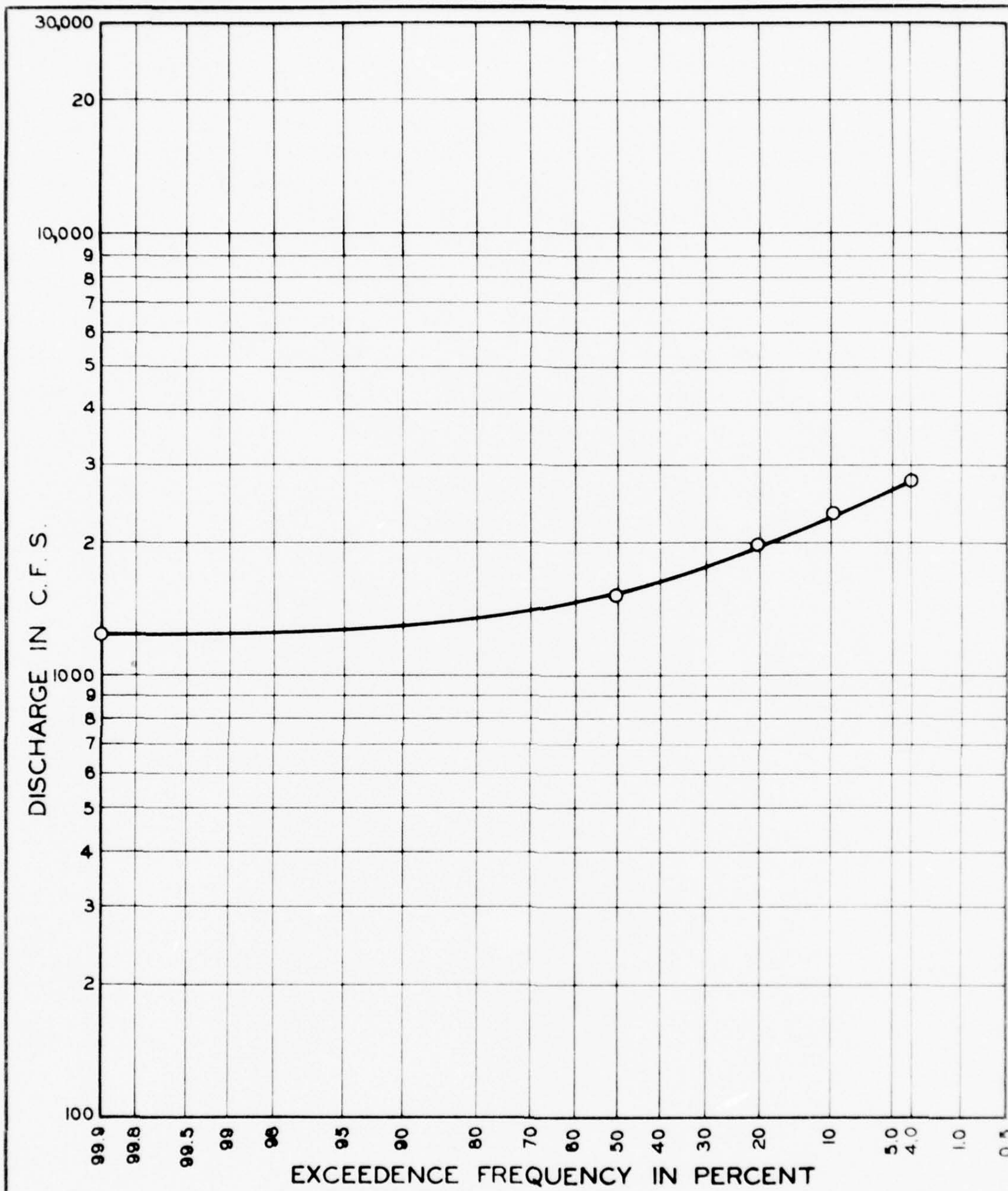
25 yr rain = 0.15 in. I = 0.15 in/hr. T_c = 60 min F_{av} = 0.10 in/hr.
Q_{25} = 0.69 (0.15-0.10) 1,680 = 58 c.f.s.
VOL_{25} = 4.9 ac-ft. $Runoff_{25}$ = 0.035 in.

10 yr rain = 0.14 in. I = 0.14 in/hr. F_{av} = 0.10 in/hr.
Q_{10} = 0.68 (0.14-0.10) 1,680 = 46 c.f.s.
VOL_{10} = 3.8 ac-ft. $Runoff_{10}$ = 0.027 in.

5 Yr rain = 0.12 in. I = 0.12 in/hr. F_{av} = 0.10 in/hr.
Q_5 = 0.67 (0.12-0.10) 1,680 = 23 c.f.s.
VOL_5 = 1.8 ac-ft. $Runoff_5$ = 0.013 in.

2 yr rain = 0.08 in. I = 0.08 in/hr. F_{av} = 0.08 in/hr.
Q_2 = 0
V_2 = 0

1 yr rain = 0.06 in/hr. I = 0.06 in/hr. F_{av} = 0.06 in/hr.
Q_1 = 0
V_1 = 0



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
DISCHARGE - FREQUENCY
5A
GRACE STREET SEWER SERVICE AREA
DRAINAGE AREA - 1,680 ACRES

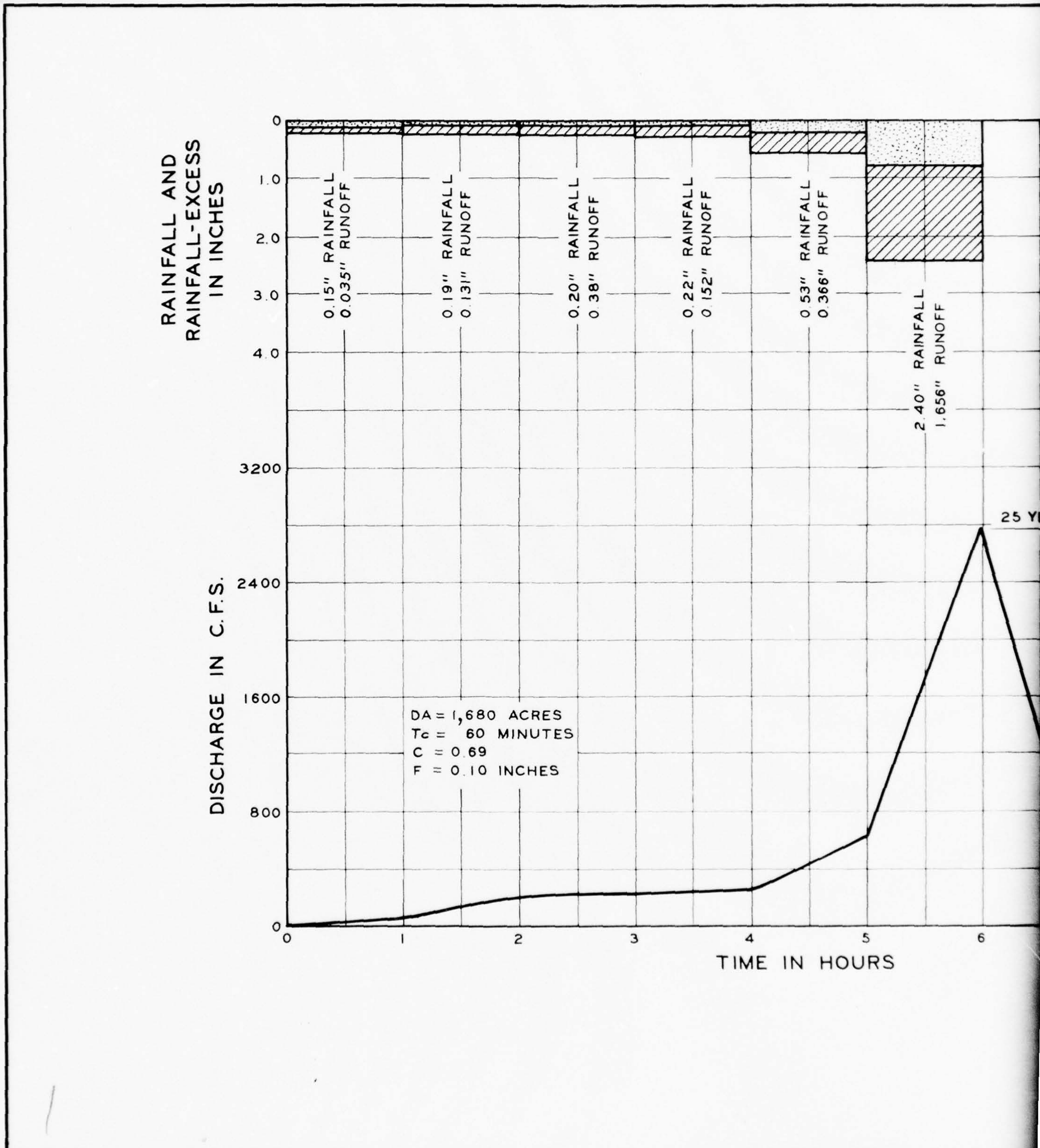
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

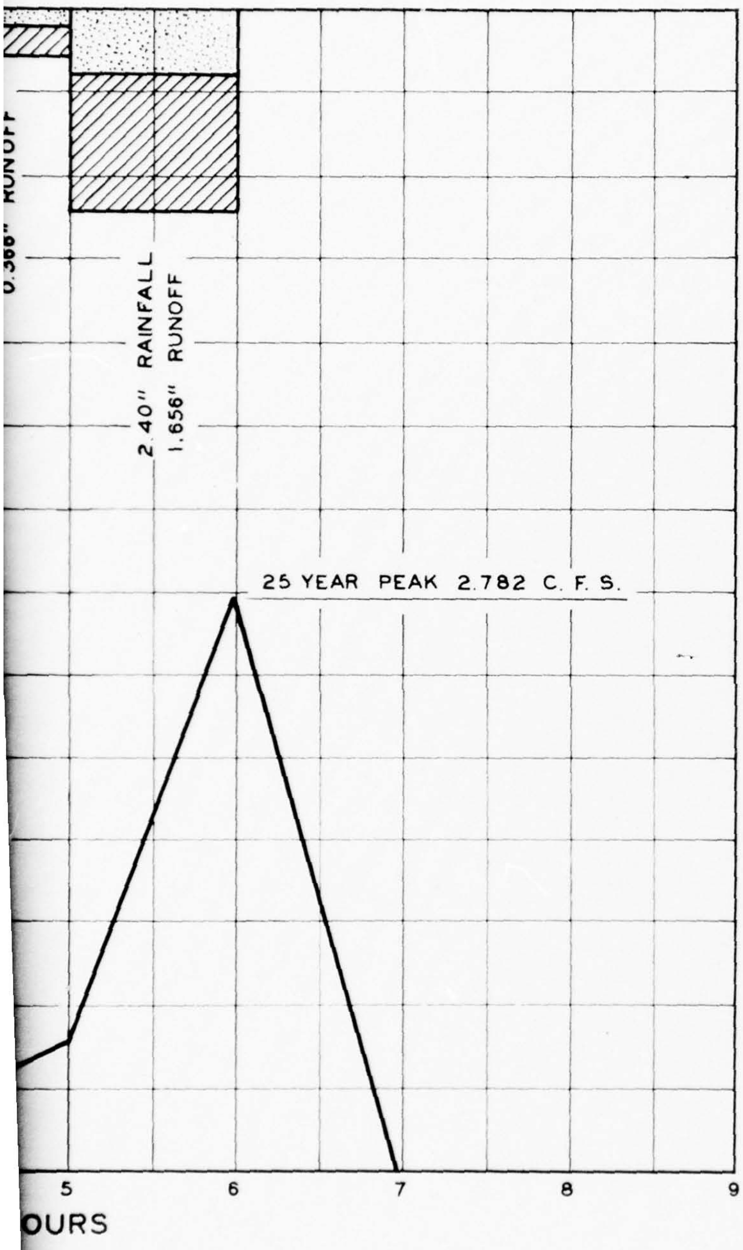
11A. "U" Street Sewer Service Area
20. "U" Street Outlet

12A. Carter Lake Sewer Service Area
21. Carter Lake Outlet
22. Airport Outlet

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
OMAHA-MISSOURI RIVER
SEWER SERVICE AREA BASIN MAP
US ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

VOLUME V ANNEX C PLATE I





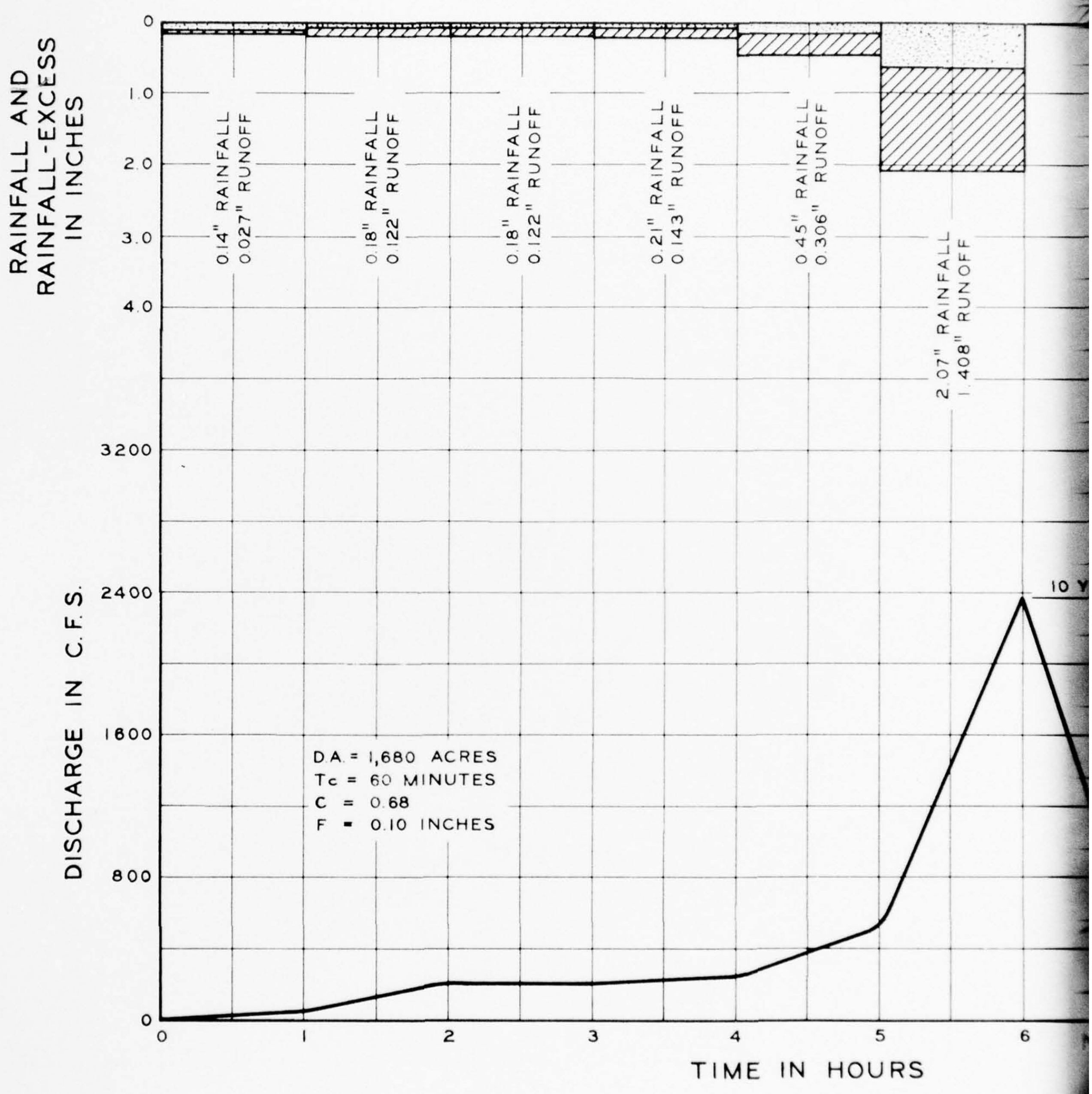
DURATION	RAIN (in.)	RUNOFF (in)	VOLUME (ac.-ft.)
1-HR.	0.15	0.035	4.9
2-HR.	0.19	0.131	18.3
3-HR.	0.20	0.138	19.3
4-HR.	0.22	0.152	21.3
5-HR.	0.53	0.366	51.2
6-HR.	2.40	1.656	231.7
MAX 6-HR	3.69	2.477	346.6
MAX 24-HR	5.06	3.422	478.8

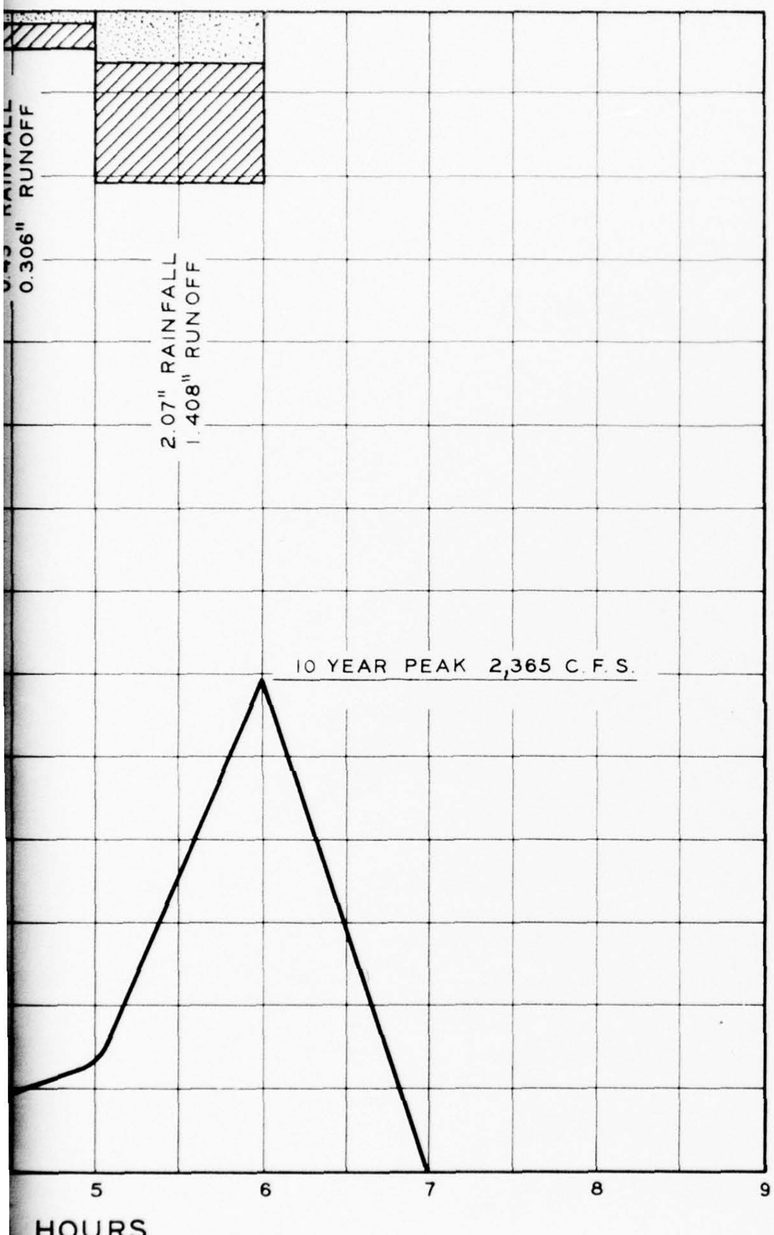
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

5A

GRACE STREET SEWER SERVICE AREA
25 YEAR STORM HYDROGRAPH

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975


RAINFALL AND RAINFALL-EXCESS IN INCHES
DISCHARGE IN C.F.S.
TIME IN HOURS
0
1.0
2.0
3.0
4.0
3200
2400
1600
800
0
0
1
2
3
4
5
6
0.14" RAINFALL
0.027" RUNOFF
0.18" RAINFALL
0.122" RUNOFF
0.18" RAINFALL
0.122" RUNOFF
0.21" RAINFALL
0.143" RUNOFF
0.45" RAINFALL
0.306" RUNOFF
2.07" RAINFALL
1.408" RUNOFF
D.A. = 1,680 ACRES
Tc = 60 MINUTES
C = 0.68
F = 0.10 INCHES



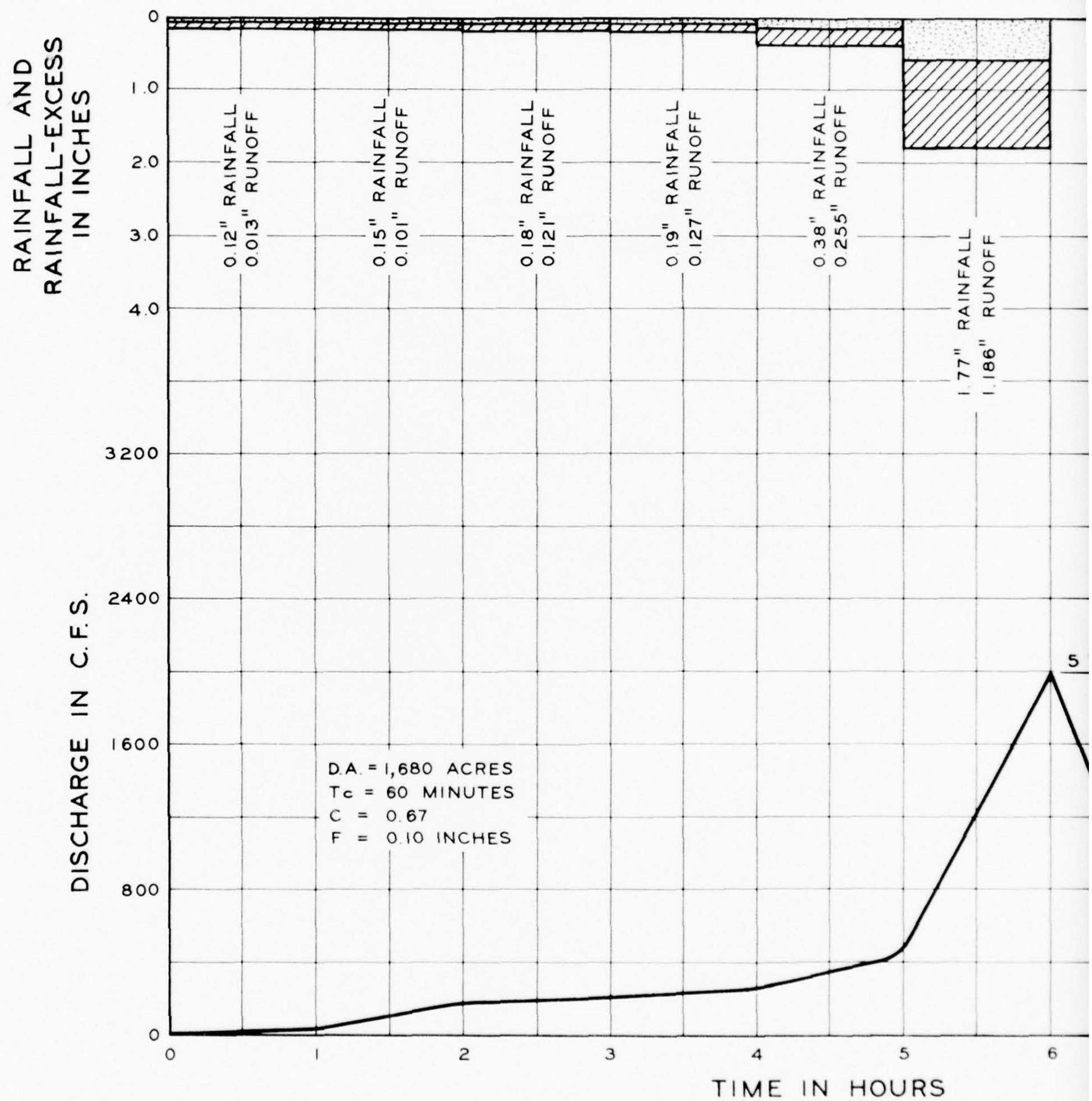
DURATION	RAIN (in.)	RUNOFF (in.)	VOLUME (ac-ft.)
1-HR	0.14	0.027	3.8
2-HR	0.18	0.122	17.1
3-HR	0.18	0.122	17.1
4-HR	0.21	0.143	20.0
5-HR	0.45	0.306	42.8
6-HR	2.07	1.408	197.0
MAX 6-HR	3.23	2.128	297.7
MAX 24-HR	4.41	2.931	410.1

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

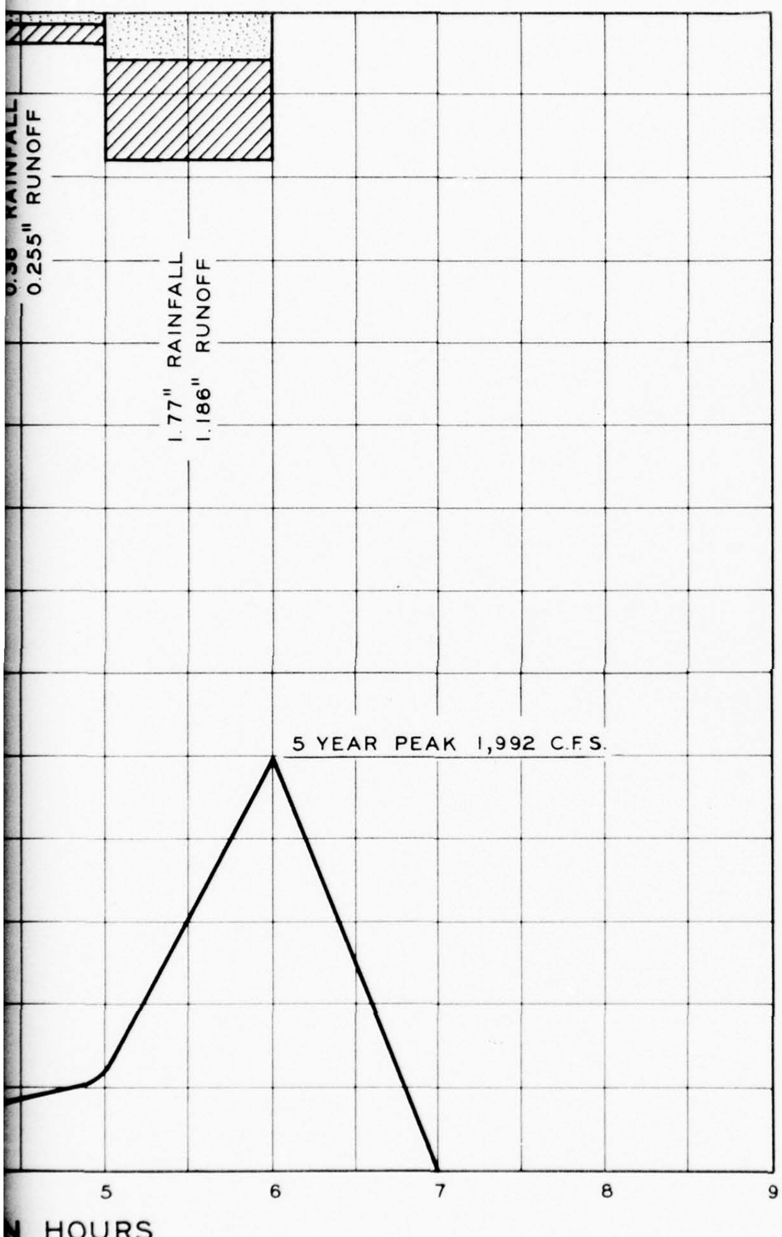
5A

GRACE STREET SEWER SERVICE AREA
10 YEAR STORM HYDROGRAPH

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS. OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



RAINFALL AND
RAINFALL-EXCESS
IN INCHES
0
1.0
2.0
3.0
4.0
0.12" RAINFALL
0.013" RUNOFF
0.15" RAINFALL
0.101" RUNOFF
0.18" RAINFALL
0.121" RUNOFF
0.19" RAINFALL
0.127" RUNOFF
0.38" RAINFALL
0.255" RUNOFF
1.77" RAINFALL
1.186" RUNOFF
DISCHARGE IN C.F.S.
3200
2400
1600
800
0
D.A. = 1,680 ACRES
Tc = 60 MINUTES
C = 0.67
F = 0.10 INCHES
0
1
2
3
4
5
6
TIME IN HOURS



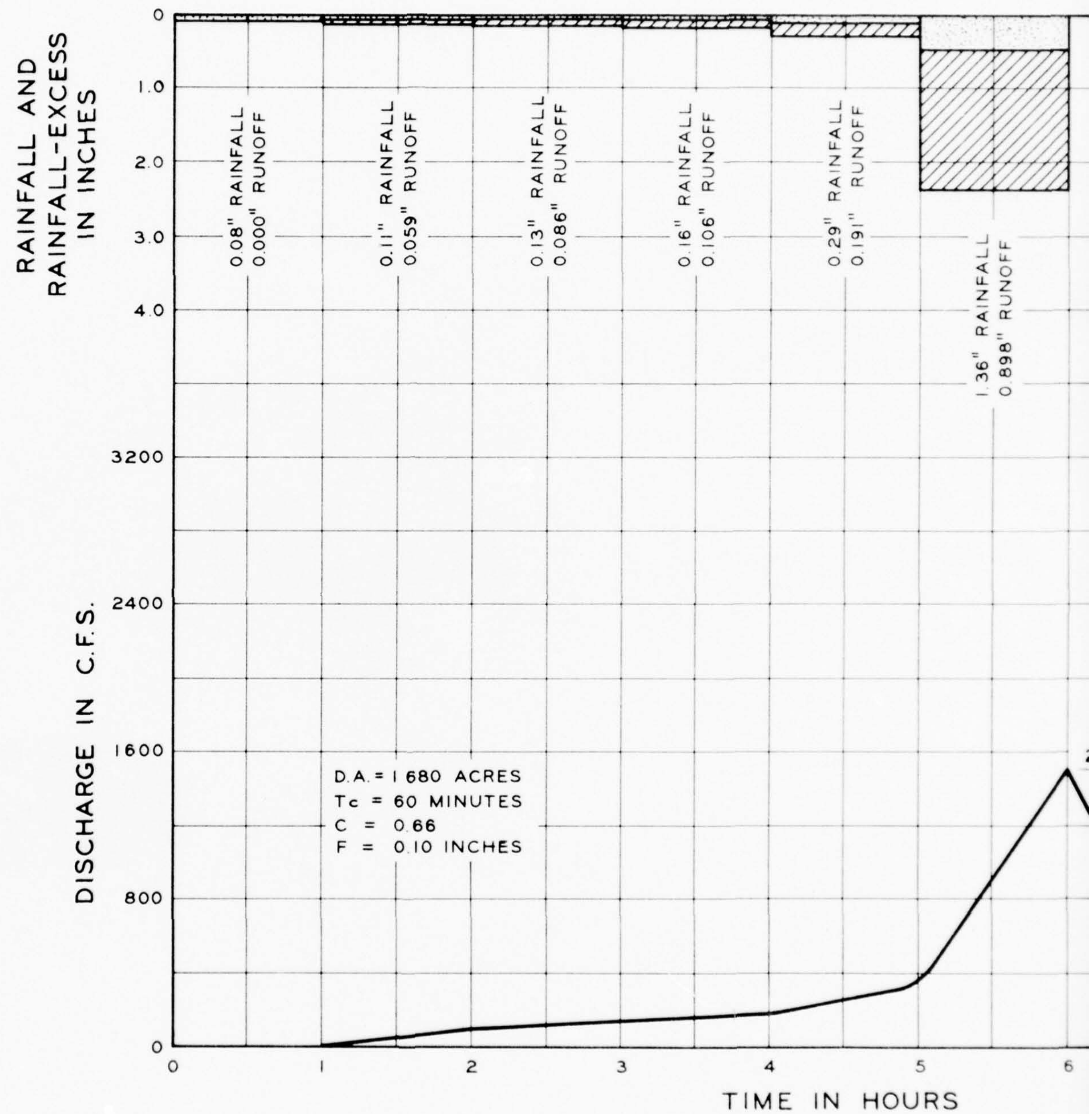
DURATION	RAIN (in.)	RUNOFF (in.)	VOLUME (ac-ft.)
1-HR	0.12	0.013	1.8
2-HR	0.15	0.101	14.1
3-HR	0.18	0.121	16.9
4-HR	0.19	0.127	17.7
5-HR	0.38	0.255	35.7
6-HR	1.77	1.186	165.9
MAX 6-HR	2.79	1.802	252.1
MAX 24-HR	3.79	2.472	345.9

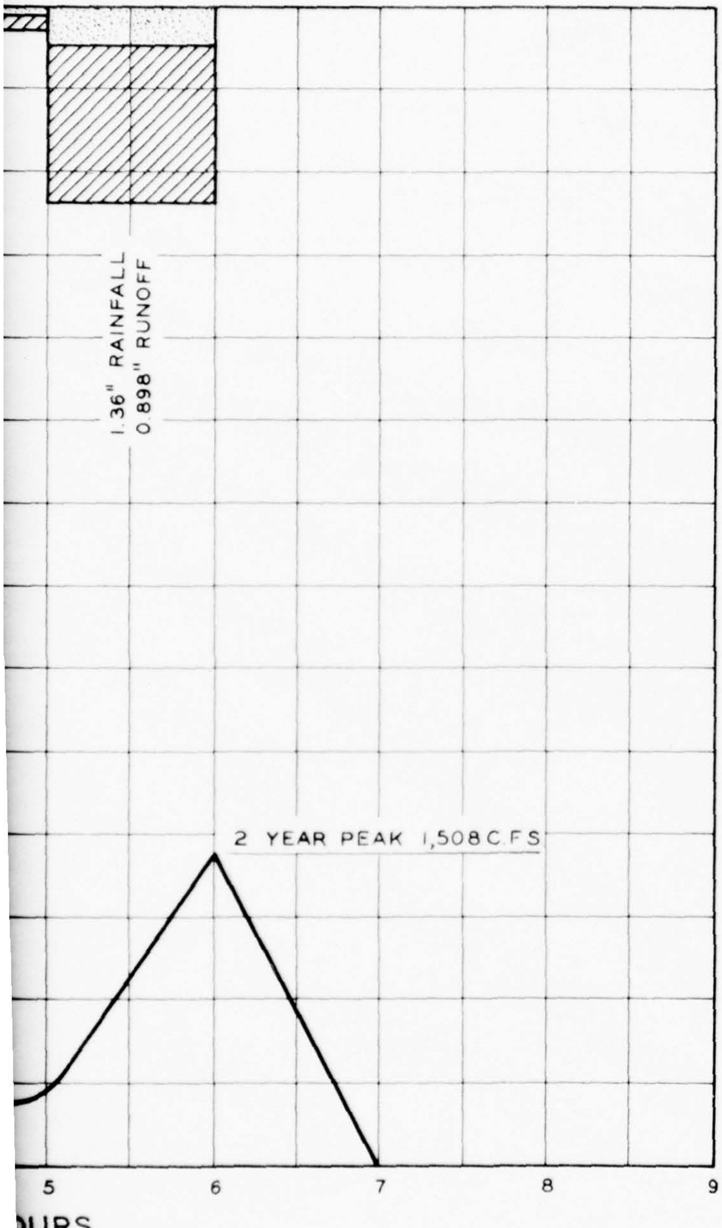
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

5A

GRACE STREET SEWER SERVICE AREA
5 YEAR STORM HYDROGRAPH

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975


RAINFALL AND RAINFALL-EXCESS IN INCHES
0
1.0
2.0
3.0
4.0
0.08" RAINFALL
0.000" RUNOFF
0.11" RAINFALL
0.059" RUNOFF
0.13" RAINFALL
0.086" RUNOFF
0.16" RAINFALL
0.106" RUNOFF
0.29" RAINFALL
0.191" RUNOFF
1.36" RAINFALL
0.898" RUNOFF
DISCHARGE IN C.F.S.
3200
2400
1600
800
0
D.A. = 1 680 ACRES
Tc = 60 MINUTES
C = 0.66
F = 0.10 INCHES
0
1
2
3
4
5
6
TIME IN HOURS



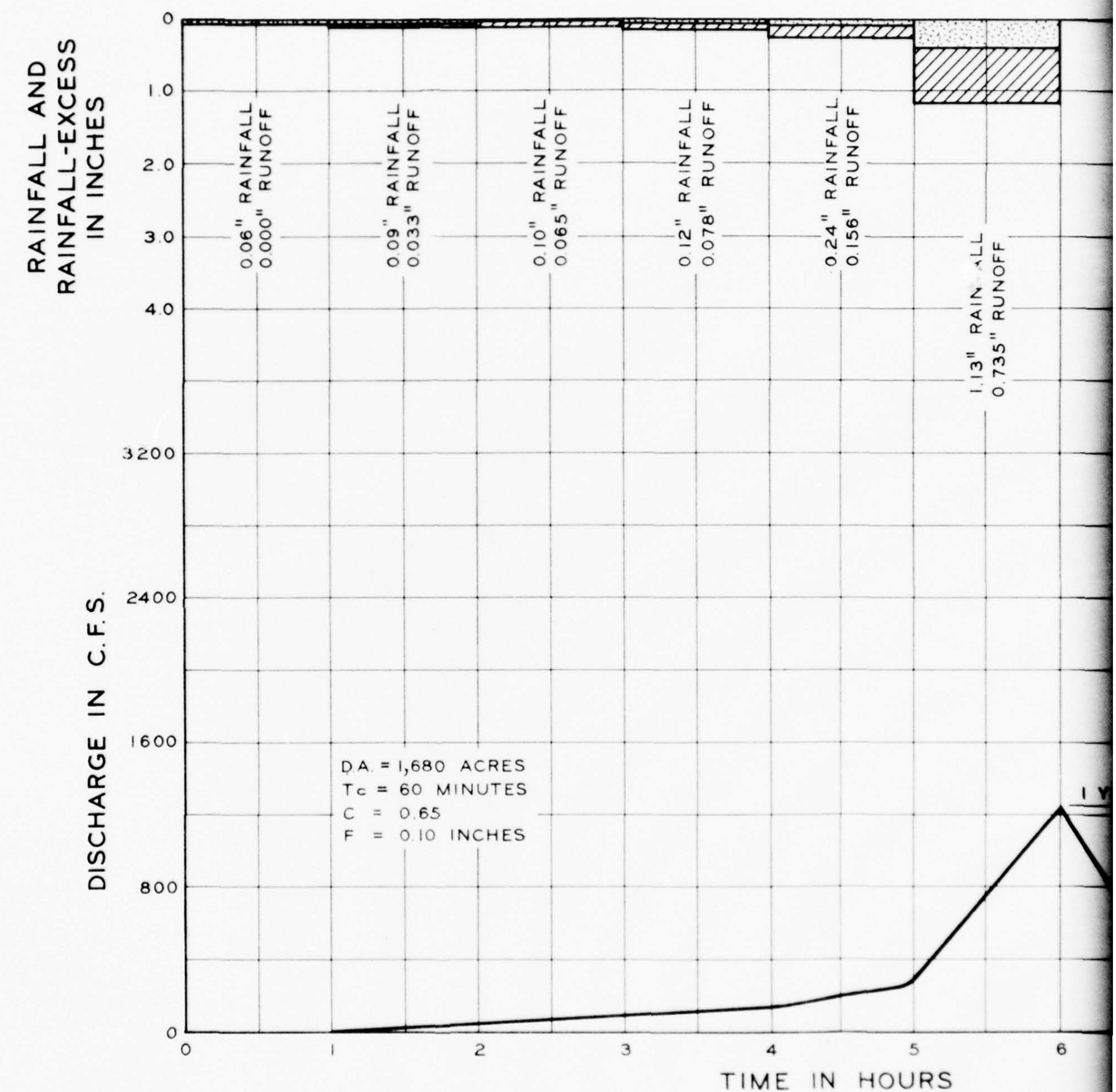
DURATION	RAIN (in.)	RUNOFF (in.)	VOLUME (ac-ft.)
1-HR	0.08	0.000	0.0
2-HR	0.11	0.059	8.3
3-HR	0.13	0.086	12.0
4-HR	0.16	0.106	14.8
5-HR	0.29	0.191	26.7
6-HR	1.36	0.898	125.6
MAX 6-HR	2.13	1.340	187.5
MAX 24-HR	2.92	1.861	260.4

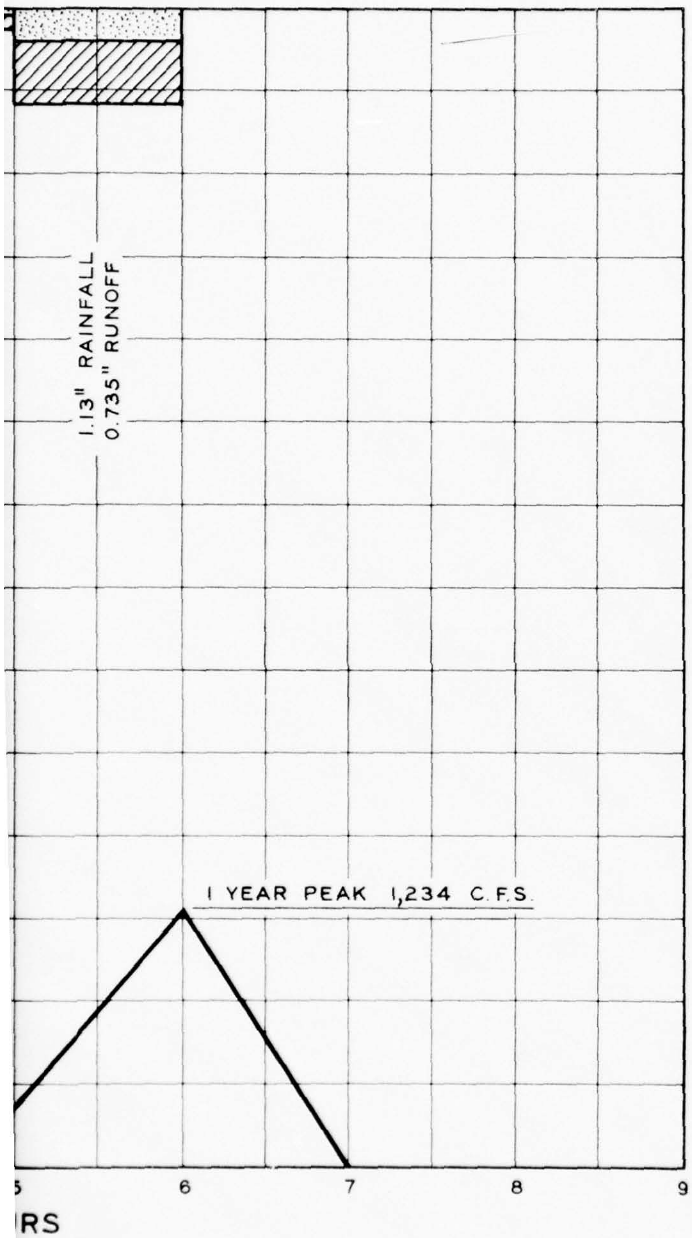
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

5A

GRACE STREET SEWER SERVICE AREA
2 YEAR STORM HYDROGRAPH

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975


RAINFALL AND
RAINFALL-EXCESS
IN INCHES
DISCHARGE IN C.F.S.
0.06" RAINFALL
0.000" RUNOFF
0.09" RAINFALL
0.033" RUNOFF
0.10" RAINFALL
0.065" RUNOFF
0.12" RAINFALL
0.078" RUNOFF
0.24" RAINFALL
0.156" RUNOFF
1.13" RAINFALL
0.735" RUNOFF
D.A. = 1,680 ACRES
Tc = 60 MINUTES
C = 0.65
F = 0.10 INCHES
TIME IN HOURS



DURATION	RAIN (in.)	RUNOFF (in.)	VOLUME (ac-ft.)
1-HR	0.06	0.000	0.0
2-HR	0.09	0.033	4.6
3-HR	0.10	0.065	9.1
4-HR	0.12	0.078	10.9
5-HR	0.24	0.156	21.8
6-HR	1.13	0.735	102.8
MAX 6-HR	1.74	1.066	149.2
MAX 24-HR	2.41	1.502	210.2

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

5A

GRACE STREET SEWER SERVICE AREA
1 YEAR STORM HYDROGRAPH

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

URBAN WATERSHED DATA

NAMEWS	MXLG	EXPTE	REFF
MISSOURI RIVER	5	4.600	.010

AREA	CPERV	CIMP	RFU	IOU	DVU	DVUMX	WU
21113.00	.15	1.00	1.00	-0	-0.00	-0.00	-0.00

DEPRESSION STORAGE (INCHES) .100

DAILY EVAPORATION RATES FOR EACH MONTH, JAN-DEC IN INCHES/DAY
.15 .15 .20 .21 .26 .29 .29 .26 .15 .15 .15 .15

INPUT DATA DESCRIBING LAND USE AND POLLUTANTS

LNDUSE	PRCNT	FIMP	STLEN	NCLEAN	DD	POUNDS POLLUTANT PER 100LB DD				
						SUSP	SETL	BOD	N	PO4
SINGLE	20.0	40.0	300.0	45	-0.00	-0.00	-0.000	-0.000	-0.000	-0.000
MULTPL	48.0	55.0	350.0	45	-0.00	-0.00	-0.000	-0.000	-0.000	-0.000
COMMCL	10.0	95.0	100.0	7	-0.00	-0.00	-0.000	-0.000	-0.000	-0.000
INDSTL	7.0	80.0	100.0	7	-0.00	-0.000	-0.000	-0.000	-0.000	-0.000
OPEN	15.0	1.0	20.0	100	-0.00	-0.000	-0.000	-0.000	-0.000	-0.000

COMPUTED RUNOFF COEFFICIENT FOR WATERSHED IS .57202

FRACTION OF URBAN WATERSHED THAT IS IMPERVIOUS IS .4965

LAND USE AND POLLUTANT DATA WITH DEFAULT VALUES ADDED

LAND USE	PRCNT OF LND AREA	PRCNT IMPERV	GUTTERS FT/AC	SWEEPING INTRVL, DYS	DD RATE LBS/DAY	********** LBS POLLUTANT/100LBS DD ********** SUSP	SETL	BOD	N	PO4
SINGLE	20.0	40.0	300.0	45	8867.5	11.100	1.100	.500	.048	.005
MULTPL	48.0	55.0	350.0	45	81580.6	8.000	.800	.360	.061	.005
COMMCL	10.0	95.0	100.0	7	6967.3	17.000	1.700	.770	.041	.007
INDSTL	7.0	80.0	100.0	7	6798.4	6.700	.700	.300	.043	.003
OPEN	15.0	1.0	20.0	100	950.[illegible]	11.100	1.100	.500	.046	.005

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PAGE    1                            MISSOURI RIVER SEWER SERVICE AREA
                                                   QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR.   212.9 CFS.   137.594 MGD                                     EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY=  .0000 INCHES.     .0 AC-FT.     .001 MG                                       MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 **10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF 1359 EVENTS   130.4** 3.8  3.7    .45    .23     .7   4.4   .00     0.0*                   5.0   .04   .5  2.6  2.6  1.5  1.5
AVE OF 1359 OVRFLW EVENTS    3.8  3.7    .45    .23     .7   4.4  (.00*    1.0 3.3   .20    .16   5.0   .04   .5  2.6  2.6  1.5  1.5

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS


          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          ------------------------------------------------------------------------------------------------


          NUMBER OF EVENTS =      56.6

          NUMBER OF OVERFLOWS =   56.6

                                        INCHES
                                        ------

          TOTAL PRECIPITATION ON WATERSHED    30.46

          TOTAL RUNOFF FROM WATERSHED         13.35     FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER         11.19     FRACTION OF RAINFALL = .37,  OF RUNOFF = .84

          INITIAL OVERFLOW TO RECIEVING WATER  8.80     FRACTION OF RAINFALL = .29,  OF RUNOFF = .66
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PAGE    1                                   MISSOURI RIVER SEWER SERVICE AREA
                                                        QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR.   212.9 CFS.   137.594 MGD                                  EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY=  .0400 INCHES.   70.4 AC-FT.  22.936 MG                                     MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22

AVE OF 1183 EVENTS   147.1** 5.2  4.6    .52    .27    3.0   8.2   .03     1.7*                    8.6   .08  2.1  5.2  6.4  2.4  2.6
AVE OF  857 OVRFLW EVENTS    6.2  5.5    .69    .36    3.5   9.6   .02*    1.7 3.7   .26   .20     9.9   .10  2.5  6.3  7.8  3.0  3.2

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS
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          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          -------------------------------------------------------------------------------------------------

          NUMBER OF EVENTS =      49.3

          NUMBER OF OVERFLOWS =  35.7

                                              INCHES
                                              ------

          TOTAL PRECIPITATION ON WATERSHED     30.46

          TOTAL RUNOFF FROM WATERSHED          13.35      FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER           9.38      FRACTION OF RAINFALL = .31.  OF RUNOFF = .70

          INITIAL OVERFLOW TO RECIEVING WATER   7.16      FRACTION OF RAINFALL = .24.  OF RUNOFF = .54
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                                    MISSOURI RIVER SEWER SERVICE AREA
                                             QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR,   212.9 CFS,   137.594 MGD                                  EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY=  .0800 INCHES,  140.8 AC-FT,  45.872 MG                                     MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF 1136 EVENTS   150.5** 6.1  5.0    .55    .28    5.1  11.2   .06     2.3*                  11.5   .11  3.2  7.4  9.4  3.2  3.5
AVE OF  643 OVRFLW EVENTS  8.0  6.4    .86    .45    6.8  14.8   .03*    2.2 4.0   .30    .23  15.0   .15  4.5 10.4 13.1  4.5  4.9

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS


          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          -----------------------------------------------------------------------------------------------------


          NUMBER OF EVENTS =     47.3

          NUMBER OF OVERFLOWS =  26.8
                                                INCHES
                                                ------

          TOTAL PRECIPITATION ON WATERSHED     30.46

          TOTAL RUNOFF FROM WATERSHED          13.35      FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER           8.15      FRACTION OF RAINFALL = .27,  OF RUNOFF = .61

          INITIAL OVERFLOW TO RECIEVING WATER   6.29      FRACTION OF RAINFALL = .21,  OF RUNOFF = .47
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PAGE    1                              MISSOURI RIVER SEWER SERVICE AREA
                                                   QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR.   212.9 CFS.   137.594 MGD
STORAGE CAPACITY=  .1000 INCHES.  175.9 AC-FT,  57.339 MG                                   EPPLEY AIRFIELD U.S.W.B.
                                                                                             MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF 1124 EVENTS   151.0** 6.3  5.1    .55    .28    6.1  12.4   .07      2.4*                    12.8   .12  3.7  8.4 10.6  3.6  3.9
AVE OF  584 OVRFLW EVENTS    8.7  6.7    .92    .48    8.6  17.3   .04*     2.3 4.0    .31    .24  17.4   .17  5.5 12.4 15.4  5.2  5.6

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS


          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          ------------------------------------------------------------------------------------------------


          NUMBER OF EVENTS =      46.8

          NUMBER OF OVERFLOWS =  24.3

                                         INCHES
                                         ------

          TOTAL PRECIPITATION ON WATERSHED   30.46

          TOTAL RUNOFF FROM WATERSHED        13.35     FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER         7.64     FRACTION OF RAINFALL = .25,  OF RUNOFF = .57

          INITIAL OVERFLOW TO RECIEVING WATER 5.87     FRACTION OF RAINFALL = .19,  OF RUNOFF = .44
```

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PAGE    1                               MISSOURI RIVER SEWER SERVICE AREA
                                                      QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR.   212.9 CFS.   137.594 MGD                                EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY=  .2000 INCHES.  351.9 AC-FT. 114.679 MG                                   MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22

AVE OF 1065 EVENTS   155.0** 8.1  5.5    .59    .30    9.5  17.6   .11    3.0*                  17.9   .17  5.6 12.3 15.7  4.9  5.4
AVE OF  392 OVRFLW EVENTS   13.8  8.3   1.25    .66   16.4  30.3   .06*   3.4 4.3   .36   .26  30.4   .30 10.2 22.3 28.3  8.6  9.6

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS


          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          -----------------------------------------------------------------------------------------------


          NUMBER OF EVENTS =      44.4

          NUMBER OF OVERFLOWS =  15.9

                                          INCHES
                                          ------

          TOTAL PRECIPITATION ON WATERSHED   30.46

          TOTAL RUNOFF FROM WATERSHED        13.35      FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER         5.67      FRACTION OF RAINFALL = .19,  OF RUNOFF = .42

          INITIAL OVERFLOW TO RECIEVING WATER 4.21      FRACTION OF RAINFALL = .14,  OF RUNOFF = .32
```

```
PAGE    1                          MISSOURI RIVER SEWER SERVICE AREA
                                                QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR,   212.9 CFS,   137.594 MGD                                           EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY=  .4000 INCHES,  703.8 AC-FT, 229.358 MG                                              MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF 1007 EVENTS    158.4**10.8  5.9     .63     .32    13.5  24.2   .17     3.5*                  24.6    .24  8.1 16.9 21.7  6.5  7.4
AVE OF  208 OVRFLW EVENTS  26.7 11.5   1.82    .96    31.5  58.2   .10*    7.3 4.4   .38    .28  58.4    .58 20.1 40.3 53.3 15.3 17.8

* NON-OVERFLOW EVENTS ONLY,
**EXCLUDING 18 DRY PERIODS


            AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
            ------------------------------------------------------------------------------------------------


            NUMBER OF EVENTS =      42.0

            NUMBER OF OVERFLOWS =    8.7

                                         INCHES
                                         ------

            TOTAL PRECIPITATION ON WATERSHED    30.46

            TOTAL RUNOFF FROM WATERSHED         13.35     FRACTION OF RAINFALL = .44

            OVERFLOW TO RECEIVING WATER          3.31     FRACTION OF RAINFALL = .11,  OF RUNOFF = .25

            INITIAL OVERFLOW TO RECIEVING WATER  2.44     FRACTION OF RAINFALL = .08,  OF RUNOFF = .18
```

```
PAGE    1                         MISSOURI RIVER SEWER SERVICE AREA
                                            QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR,   212.9 CFS,   137.594 MGD                                  EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY=  .6000 INCHES, 1055.6 AC-FT, 344.036 MG                                     MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF  984 EVENTS    158.9**12.5  6.1    .64    .32   15.5  28.0   .20     4.3*                    28.4   .28  9.4 19.1 24.6  7.3  8.4
AVE OF  117 OVRFLW EVENTS   41.1 14.3   2.43   1.28   46.5  87.6   .14*   11.1 4.5    .41    .31  87.8   .87 29.0 56.9 77.0 21.5 25.6

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS

          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          -----------------------------------------------------------------------------------------------


          NUMBER OF EVENTS =      41.0

          NUMBER OF OVERFLOWS =    4.9

                                            INCHES
                                            ------

          TOTAL PRECIPITATION ON WATERSHED    30.46

          TOTAL RUNOFF FROM WATERSHED         13.35     FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER          2.00     FRACTION OF RAINFALL = .07,  OF RUNOFF = .15

          INITIAL OVERFLOW TO RECIEVING WATER  1.53     FRACTION OF RAINFALL = .05,  OF RUNOFF = .11
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PAGE    1                       MISSOURI RIVER SEWER SERVICE AREA
                                                QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR,   212.9 CFS,   137.594 MGD                                          EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY=  .8000 INCHES, 1407.5 AC-FT, 458.715 MG                                             MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF  975 EVENTS    158.5**13.4  6.2     .65     .33  16.8  30.1   .21      4.6*                 30.5   .30 10.3 20.2 26.2  7.7  8.9
AVE OF   71 OVRFLW EVENTS   56.2 16.7     3.02    1.60  62.2 118.4   .17*   18.7 4.6    .42   .32 118.6  1.18 39.4 70.6100.8 27.1 33.0

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS


        AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
        -----------------------------------------------------------------------------------------------


        NUMBER OF EVENTS =      40.6

        NUMBER OF OVERFLOWS =   3.0

                                          INCHES
                                          ------

        TOTAL PRECIPITATION ON WATERSHED   30.46

        TOTAL RUNOFF FROM WATERSHED        13.35    FRACTION OF RAINFALL = .44

        OVERFLOW TO RECEIVING WATER         1.24    FRACTION OF RAINFALL = .04,  OF RUNOFF = .09

        INITIAL OVERFLOW TO RECIEVING WATER  .96    FRACTION OF RAINFALL = .03,  OF RUNOFF = .07
```

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PAGE    1                               MISSOURI RIVER SEWER SERVICE AREA
                                                       QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR,   212.9 CFS,   137.594 MGD                                      EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY=  .9000 INCHES, 1583.5 AC-FT, 516.054 MG                                          MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
*****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF  949 EVENTS   158.8**14.0  6.3    .65    .33   17.0  31.0   .22      5.0*                     31.4   .31 10.5 20.6 26.6  7.8  9.0
AVE OF   57 OVRFLW EVENTS   66.0 17.1   3.28   1.74   67.4 133.3   .18*   17.7 4.6    .41    .32 133.5  1.33 44.8 76.5107.9 29.3 35.7

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS


            AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
            ------------------------------------------------------------------------------------------------


            NUMBER OF EVENTS =      40.4

            NUMBER OF OVERFLOWS =    2.4

                                                   INCHES
                                                   ------

            TOTAL PRECIPITATION ON WATERSHED        30.46

            TOTAL RUNOFF FROM WATERSHED             13.35     FRACTION OF RAINFALL = .44

            OVERFLOW TO RECEIVING WATER               .97     FRACTION OF RAINFALL = .03,  OF RUNOFF = .07

            INITIAL OVERFLOW TO RECIEVING WATER      .75     FRACTION OF RAINFALL = .02,  OF RUNOFF = .06
```

```
PAGE    1                          MISSOURI RIVER SEWER SERVICE AREA
                                                QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR.   212.9 CFS.   137.594 MGD                                     EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY= 1.0000 INCHES, 1759.4 AC-FT, 573.394 MG                                        MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF  961 EVENTS    159.6**14.9  6.3    .66    .33   16.9  31.8   .22     5.1*                   32.2   .31 10.7 20.9 27.1  7.9  9.2
AVE OF   48 OVRFLW EVENTS    83.2 18.7   3.54   1.87   66.8 150.1   .18*   19.2 4.5   .38   .29 150.2  1.50 44.9 82.8118.4 31.7 39.1

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS


            AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
            ------------------------------------------------------------------------------------------------


            NUMBER OF EVENTS =      40.0

            NUMBER OF OVERFLOWS =    2.0
                                                INCHES
                                                ------

            TOTAL PRECIPITATION ON WATERSHED    30.46

            TOTAL RUNOFF FROM WATERSHED         13.35    FRACTION OF RAINFALL = .44

            OVERFLOW TO RECEIVING WATER           .75    FRACTION OF RAINFALL = .02,  OF RUNOFF = .06

            INITIAL OVERFLOW TO RECIEVING WATER   .57    FRACTION OF RAINFALL = .02,  OF RUNOFF = .04
```

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PAGE    1                         MISSOURI RIVER SEWER SERVICE AREA
                                                  QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR,    212.9 CFS,    137.594 MGD                                          EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY= 1.1000 INCHES, 1935.4 AC-FT, 630.733 MG                                              MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O *---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22

AVE OF  958 EVENTS    159.7**15.4  6.4    .66     .33   16.9  32.3   .23     5.3*                  32.7   .32 10.8 21.2 27.5  8.1  9.3
AVE OF   40 OVRFLW EVENTS   92.6 19.4   3.76    1.99    71.9 164.5    .19*   18.6 4.4    .35    .27 164.7  1.64 48.4 91.4132.0 35.0 43.2

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS

          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          ----------------------------------------------------------------------------------------------------

          NUMBER OF EVENTS =      39.9

          NUMBER OF OVERFLOWS =    1.7

                                           INCHES
                                           ------

          TOTAL PRECIPITATION ON WATERSHED   30.46

          TOTAL RUNOFF FROM WATERSHED        13.35    FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER          .58    FRACTION OF RAINFALL = .02,  OF RUNOFF = .04

          INITIAL OVERFLOW TO RECIEVING WATER  .44    FRACTION OF RAINFALL = .01,  OF RUNOFF = .03
```

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PAGE     1                                   MISSOURI RIVER SEWER SERVICE AREA
                                                         QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR,   212.9 CFS,   137.594 MGD                                         EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY= 1.2000 INCHES, 2111.3 AC-FT, 688.073 MG                                               MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURIN  HRS QUANTY INCHES  EMPTY DURIN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF  953 EVENTS    160.2**16.0  6.4    .67     .33    16.9  32.9   .23     5.5*                    33.3   .33 10.9 21.4 27.7  8.1  9.4
AVE OF   29 OVRFLW EVENTS  115.8 23.1   4.23    2.23    71.6 187.4   .20*   21.8 4.4   .36     .27 187.7  1.87 51.1 98.7145.5 38.0 47.8

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS


          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          ----------------------------------------------------------------------------------------------------


          NUMBER OF EVENTS =      39.7

          NUMBER OF OVERFLOWS =    1.2

                                           INCHES
                                           ------

          TOTAL PRECIPITATION ON WATERSHED   30.46

          TOTAL RUNOFF FROM WATERSHED        13.35     FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER          .44     FRACTION OF RAINFALL = .01,  OF RUNOFF = .03

          INITIAL OVERFLOW TO RECIEVING WATER  .33     FRACTION OF RAINFALL = .01,  OF RUNOFF = .02
```

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PAGE    1                    MISSOURI RIVER SEWER SERVICE AREA
                                    QUANTITY ANALYSIS
TREATMENT RATE  =  .0100 IN/HR,   212.9 CFS,   137.594 MGD                                EPPLEY AIRFIELD U.S.W.B.
STORAGE CAPACITY= 1.3000 INCHES, 2287.2 AC-FT, 745.411 MG                                  MISSOURI RIVER

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
*****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 **10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22


AVE OF  952 EVENTS    160.1**16.1  6.4    .67    .33   17.0  33.2   .24     5.7*                 33.6   .33 11.1 21.6 28.0  8.2  9.5
AVE OF   22 OVRFLW EVENTS  121.0 23.5   4.53   2.39   82.4 203.4   .21*   30.6 4.3   .36   .27 203.5  2.03 58.4105.0154.9 40.8 50.6

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING 18 DRY PERIODS

          AVERAGE ANNUAL STATISTICS FOR 24 YEARS OF RECORD FOR THE PERIOD BEGINNING 490201 AND ENDING 721230
          -----------------------------------------------------------------------------------------------


          NUMBER OF EVENTS =      39.7

          NUMBER OF OVERFLOWS =     .9

                                        INCHES
                                        ------

          TOTAL PRECIPITATION ON WATERSHED    30.46

          TOTAL RUNOFF FROM WATERSHED         13.35     FRACTION OF RAINFALL = .44

          OVERFLOW TO RECEIVING WATER           .33     FRACTION OF RAINFALL = .01,  OF RUNOFF = .02

          INITIAL OVERFLOW TO RECIEVING WATER   .25     FRACTION OF RAINFALL = .01,  OF RUNOFF = .02
```

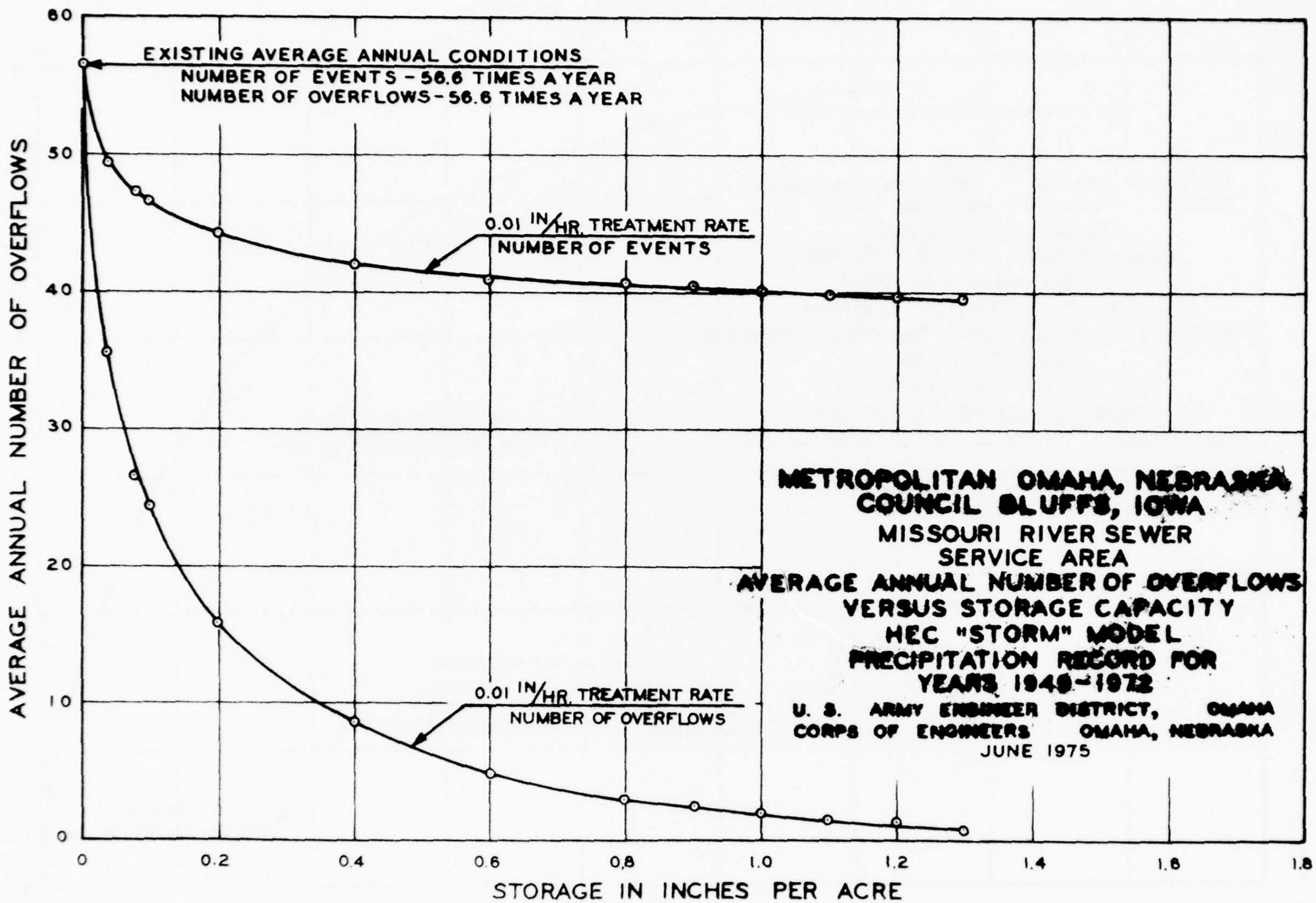
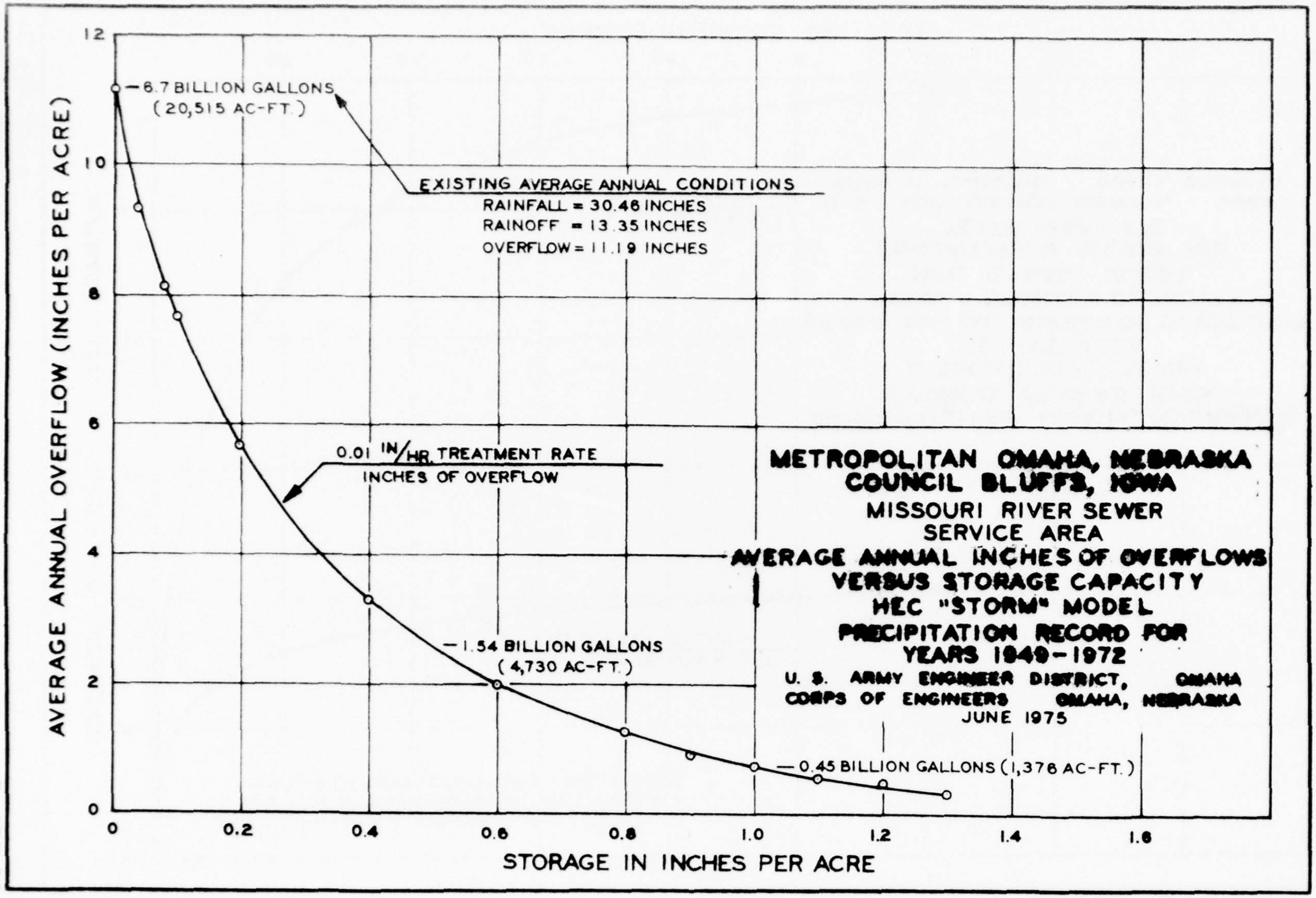
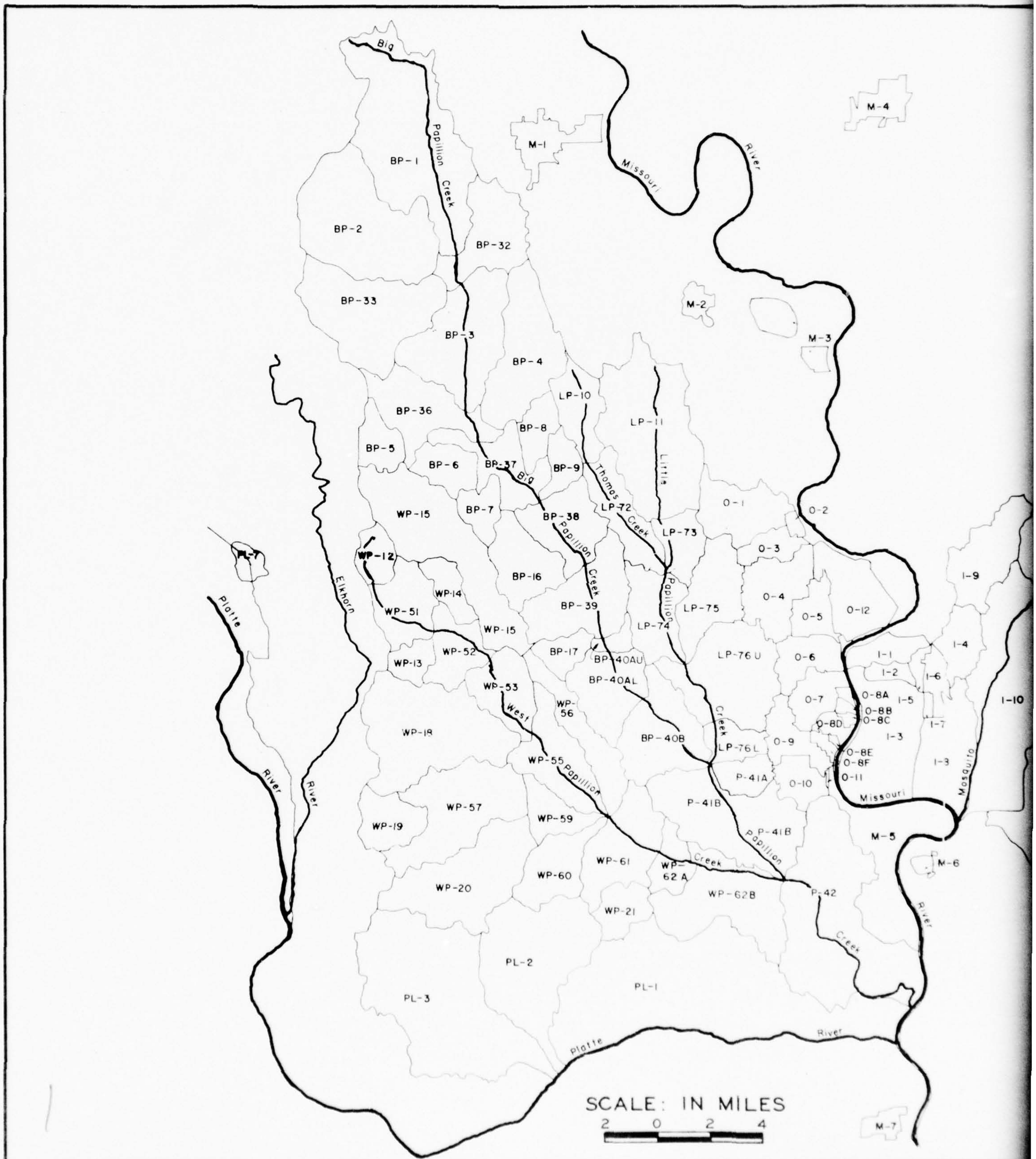

EXISTING AVERAGE ANNUAL CONDITIONS
NUMBER OF EVENTS - 56.6 TIMES A YEAR
NUMBER OF OVERFLOWS - 56.6 TIMES A YEAR
0.01 IN/HR. TREATMENT RATE
NUMBER OF EVENTS
0.01 IN/HR. TREATMENT RATE
NUMBER OF OVERFLOWS
AVERAGE ANNUAL NUMBER OF OVERFLOWS
STORAGE IN INCHES PER ACRE
0
10
20
30
40
50
60
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
MISSOURI RIVER SEWER
SERVICE AREA
AVERAGE ANNUAL NUMBER OF OVERFLOWS
VERSUS STORAGE CAPACITY
HEC "STORM" MODEL
PRECIPITATION RECORD FOR
YEARS 1949-1972
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

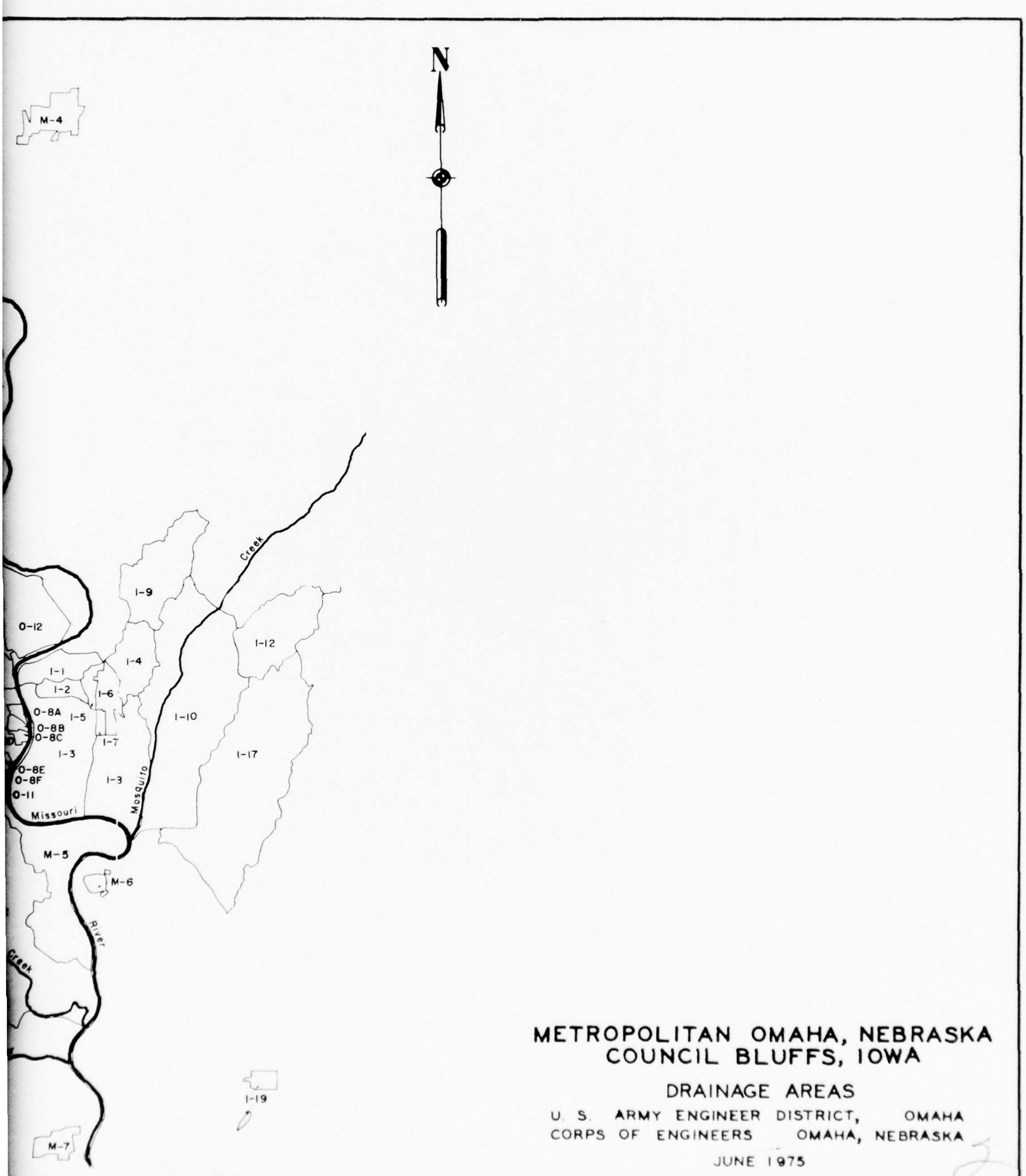
PLATE 31



AVERAGE ANNUAL OVERFLOW (INCHES PER ACRE)
STORAGE IN INCHES PER ACRE
0
2
4
6
8
10
12
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
— 6.7 BILLION GALLONS
(20,515 AC-FT.)
EXISTING AVERAGE ANNUAL CONDITIONS
RAINFALL = 30.48 INCHES
RAINOFF = 13.35 INCHES
OVERFLOW = 11.19 INCHES
0.01 IN/HR. TREATMENT RATE
INCHES OF OVERFLOW
— 1.54 BILLION GALLONS
(4,730 AC-FT.)
— 0.45 BILLION GALLONS (1,378 AC-FT.)
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
MISSOURI RIVER SEWER
SERVICE AREA
AVERAGE ANNUAL INCHES OF OVERFLOWS
VERSUS STORAGE CAPACITY
HEC "STORM" MODEL
PRECIPITATION RECORD FOR
YEARS 1949-1972
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



Big
Papillion
Creek
M-1
Missouri
River
M-4
BP-1
BP-2
BP-32
BP-33
M-2
M-3
BP-3
BP-4
LP-10
LP-11
BP-36
BP-8
BP-5
BP-6
BP-37
Big
BP-9
Thomas
Creek
Little
O-1
O-2
WP-15
BP-7
BP-38
Papillion
Creek
LP-72
LP-73
Papillion
PL-7
WP-12
O-3
BP-16
1-9
WP-14
Elkhorn
Platte
WP-51
BP-39
LP-75
O-4
O-5
O-12
WP-15
LP-74
1-4
1-1
BP-17
WP-52
BP-40AU
LP-76 U
O-6
1-2
1-6
WP-13
BP-40AL
WP-53
O-8A
1-5
O-7
1-10
WP-56
West
O-8B
O-8C
O-8D
Creek
1-7
WP-18
BP-40B
1-3
LP-76L
O-9
O-8E
O-8F
WP-55
Papillion
P-41A
O-10
O-11
1-3
River
River
Mosquito
Missouri
WP-57
P-41B
WP-59
WP-19
P-41B
M-5
Papillion
WP-61
Creek
WP-62 A
M-6
WP-60
WP-20
P-42
WP-62B
WP-21
Creek
River
PL-2
PL-1
PL-3
Platte
River
SCALE: IN MILES
2 0 2 4
M-7



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

DRAINAGE AREAS

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA

JUNE 1975

SUMMA

Sub-Basin Designation	Total Drainage Area (Acres)	Percent of Basin Urban For Each Land Use Concept A	B	C	D	1-YEAR DESIGN TRIBUTARY STORM CONCEPT A Volume (Ac.Ft.)	CONCEPT A Peak (C.F.S.)	CONCEPT B Volume (Ac.Ft.)	CONCEPT B Peak (C.F.S.)	CONCEPT C Volume (Ac.Ft.)	CONCEPT C Peak (C.F.S.)	CONCEPT Volume (Ac.Ft.)
P-41	10,856	97.9	92.9	56.7	97.9	735	2202	706	2118	472	1415	735
P-42	15,666	80.1	62.9	59	79.3	962	3845	739	2962	739	2957	901
BP-16	3,849	66	-	9	38	148	777	-	-	20	106	86
BP-17	1,512	44	54	61	56	47	282	59	346	67	390	57
BP-32	5,049	2	2	2	2	6	27	6	27	6	27	6
BP-37	3,919	1.9	-	3.2	2	7	58	-	-	8	67	5
BP-38	4,302	74.5	-	17	34	193	1055	-	-	57	313	99
BP-39	5,928	91	44	82	91	354	1951	189	1032	348	1923	354
BP-40A	5,300	91	91	91	91	361	1845	361	1845	361	1845	361
BP-40B	5,895	90.8	93	91.3	93	424	2021	515	2453	426	2032	515
LP-11	11,504	38	-	1.5	21	254	994	-	-	15	58	142
LP-72	3,834	54.4	18	55	90	155	671	66	271	157	679	235
LP-73	2,186	85	82	99.7	97	130	1020	129	1016	162	1275	147
LP-74	3,948	91	91	91	91	266	1388	266	1388	266	1388	266
LP-75	4,302	92	92	92	88.5	282	1124	282	1124	282	1124	250
LP-76	9,726	88.2	84	84	86.9	722	2973	701	2884	593	2439	592
WP-13	1,368	62.5	2	-	54	50	379	2	12	-	-	43
WP-14	1,631	38.5	-	-	34	37	241	-	-	-	-	32
WP-15	10,075	23	-	-	24	134	470	-	-	-	-	140
WP-18	10,667	46.3	1.7	-	-	288	1052	10	39	-	-	-
WP-19	2,782	15	-	-	-	24	91	-	-	-	-	-
WP-20	8,592	100	3.5	14	97.8	516	1847	24	91	75	268	490
WP-21	2,117	88	13.2	77	85	109	563	18	90	95	492	106
WP-51	3,676	31.2	-	3.2	45	69	429	-	-	9	58	97
WP-52	3,072	100	-	-	76	179	952	-	-	-	-	136
WP-53	3,621	98.9	16	34.2	89.8	218	1210	43	233	78	426	201
WP-55	4,909	89.9	89	81.8	85	338	1336	339	1340	338	1327	323
WP-56	3,710	56	77.7	88.2	85.1	272	1160	276	1181	275	1174	282
WP-57	7,967	98.3	3	6.4	30	457	2348	15	81	34	176	140
WP-59	2,249	100	100	99.3	100	156	905	191	1119	188	1096	191
WP-60	3,639	100	20.2	100	100	291	1276	69	298	291	1276	288
WP-61	5,435	98.8	45.3	96.3	100	390	1889	283	982	375	1839	394
WP-62	9,653	92.6	31.2	71	90.5	604	2678	221	981	462	2053	524
BP-77	2,983	-	89.6	-	-	-	-	205	1079	-	-	-
WP-78	1,846	-	90.1	-	-	-	-	147	759	-	-	-
PL-6	1,705	-	100	-	-	-	-	151	778	-	-	-
I-1	1,592	73.7	73.7	56.4	100	85	716	85	716	76	647	118
I-2	725	60.6	97.7	90	100	43	360	53	453	49	419	56
I-3	7,728	40.7	50.0	30.1	35.5	320	2703	380	3210	256	2163	299
I-4	2,267	76.8	98.7	59.0	88.6	106	833	147	1072	96	702	139
I-5	449	100	100	100	100	39	323	39	323	39	323	40
I-6	1,111	100	100	100	100	105	878	102	855	99	844	92
I-7	188	100	100	100	100	17	145	15	128	12	99	14
I-8	4,360	43.5	39.7	19.2	44.2	204	1727	186	1577	114	963	213
I-9	4,508	-	6.7	-	-	-	-	18	129	-	-	-
I-10	14,908	20.5	10.4	10.0	29.[illegible]	21[illegible]	11[illegible]0	100	557	112	624	284
I-19	575	-	100	-	-	-	-	54	389	-	-	-
M-1	2,456	53.3	89.2	53.3	42.6	107	776	208	1504	107	776	96
M-2	799	30.4	100	30.4	30.4	16	117	62	453	16	117	16
M-3	1,752	-	100	-	-	-	-	102	876	-	-	-
M-4	1,718	35.8	93.0	35.8	35.8	52	378	130	944	52	378	52
M-5	7,057	40.3	35.6	24.9	46.3	279	2020	247	1783	177	1283	299
M-6	360	-	100	-	-	-	-	33	277	-	-	-
M-7	845	98.1	100	98.1	70.0	61	446	77	558	61	446	45
PL-2	10,684	8.1	-	8.1	23.0	52	193	-	-	52	193	147
PL-3	17,137	-	-	-	16.5	-	-	-	-	-	-	165
PL-5	1,463	-	100	-	-	-	-	121	625	-	-	-
PL-6	1,705	-	100	-	-	-	-	151	778	-	-	-
PL-7	823	100	100	100	13.4	53	452	61	518	53	452	10
LP-76A	8,229	89.2	83.9	84.0	87.3	569	2653	587	2718	582	2689	550
LP-76B	1,497	82.8	84.7	85.0	85.2	110	513	122	563	112	523	119

NOTES:
(1) Total Drainage Area - 1,337 acres.
(2) Total Drainage Area - 7,895 acres.
(3) Total Drainage Area - 7,786 acres.
(4) Total Drainage Area - 5,116 acres.

OMAHA-COUNCIL BLUFFS URBAN STUDY

SUMMARY OF URBAN STORM WATER RUNOFF VOLUMES AND PEAK DISCHARGES

			5-YEAR DESIGN TRIBUTARY STORM								1		
	CONCEPT D		CONCEPT A		CONCEPT B		CONCEPT C		CONCEPT D		CONCEPT A		CO
k	Volume	Peak	Volume	Peak	Volume	Peak	Volume	Peak	Volume	Peak	Volume	Peak	Volume
S.)	(Ac.Ft.)	(C.F.S.)	(Ac.Ft.)	(C.F.S)	(Ac.Ft.)	(C.F.S.)	(Ac.Ft.)	(C.F.S.)	(Ac.Ft.)	(C.F.S.)	(Ac.Ft.)	(C.F.S.)	(Ac.Ft.
5	735	2202	1461	4278	1404	4117	908	2656	1461	4278	1895	5611	1816
7	901	3581	1851	7207	1437	5619	1402	5472	1761	6877	2353	9300	1839
6	86	447	318	1606	-	-	42	219	184	925	424	2158	-
0	57	334	92	530	116	662	131	747	114	652	119	696	149
7	6	27	14	55	14	55	14	55	14	55	18	75	18
7	5	47	12	104	-	-	16	136	11	92	15	130	-
3	99	541	404	2168	-	-	110	581	197	1057	538	2917	-
3	354	1951	718	3844	368	1941	680	3617	718	3844	938	5089	476
5	361	1845	703	3470	703	3470	703	3470	703	3470	900	4506	900
2	515	2453	803	3744	920	4307	807	3765	920	4307	1022	4806	1135
8	142	549	544	2070	-	-	27	105	304	1144	726	2784	-
9	235	1018	301	1279	119	486	305	1296	467	1990	386	1654	147
5	147	1144	253	1985	251	1916	314	2411	293	2227	335	2590	325
8	266	1388	516	2639	516	2639	516	2639	516	2639	662	3417	662
4	250	987	551	2130	551	2130	551	2130	507	1960	712	2784	712
9	592	2445	1337	5407	1293	5259	1159	4666	1177	4755	1680	6839	1620
-	43	328	107	783	4	25	-	-	92	676	142	1055	5
-	32	213	78	497	-	-	-	-	69	439	104	671	-
-	140	490	288	981	-	-	-	-	299	1024	383	1317	-
-	-	-	617	2196	22	81	-	-	-	-	823	2954	30
-	-	-	52	190	-	-	-	-	-	-	69	256	-
58	490	1775	1081	3823	44	166	156	548	1050	3709	1439	5133	55
92	106	543	234	1166	37	185	204	1020	226	1126	312	1577	49
58	97	609	144	884	-	-	13	108	207	1264	192	1184	-
-	136	723	384	1972	-	-	-	-	292	1499	512	2659	-
26	201	1100	457	2450	83	445	163	878	420	2244	606	3275	107
27	323	1280	651	2505	648	2497	625	2415	619	2401	827	3229	831
74	282	1208	487	2041	492	2063	510	2133	513	2149	600	2530	605
76	140	716	979	4901	31	160	68	343	299	1496	1305	6595	40
96	191	1119	309	1751	354	2019	348	1976	354	2019	401	2312	442
76	288	1259	552	2353	123	524	552	2353	546	2334	698	3012	152
39	394	1912	761	3608	528	1783	732	3462	770	3652	980	4696	661
53	524	[illegible]	[illegible]	5238	432	[illegible]	919	4016	1099	4794	1572	6915	553
-	-	-	-	-	397	2003	-	-	-	-	-	-	508
-	-	-	-	-	268	1346	-	-	-	-	-	-	334
-	-	-	-	-	274	1379	-	-	-	-	-	-	342
47	118	1002	166	1374	166	1374	141	1164	230	1894	214	1784	214
19	56	471	76	623	103	850	97	786	107	877	93	777	132
63	299	2522	561	4620	673	5530	438	3605	516	4222	681	5688	825
02	139	1001	232	1641	298	2111	188	1324	276	1947	303	2174	390
23	40	341	71	588	71	588	71	588	73	602	89	745	89
44	92	778	187	1544	183	1522	181	1489	171	1410	231	1922	228
99	14	118	31	258	29	235	24	203	27	223	39	321	36
63	213	1810	351	2904	321	2652	192	1583	364	3004	424	3530	387
-	-	-	-	-	38	267	-	-	-	-	-	-	50
24	284	1589	425	2287	205	1107	218	1174	584	3158	550	2988	270
-	-	-	-	-	97	684	-	-	-	-	-	-	119
76	96	690	200	1416	372	2631	200	1416	173	1227	252	1809	458
17	16	117	32	231	119	838	32	231	32	231	42	306	152
-	-	-	-	-	219	1804	-	-	-	-	-	-	292
78	52	378	97	684	244	1724	97	684	97	684	121	862	307
83	299	2154	495	3484	437	3075	311	2203	539	3833	606	4335	536
-	-	-	-	-	59	490	-	-	-	-	-	-	73
46	45	332	120	844	139	992	120	844	87	614	153	1098	173
93	147	532	110	393	-	-	110	393	309	1100	146	523	-
-	165	604	-	-	-	-	-	-	354	1262	-	-	-
-	-	-	-	-	226	1129	-	-	-	-	-	-	284
-	-	-	-	-	274	1379	-	-	-	-	-	-	342
52	10	81	108	897	119	979	108	897	18	145	143	1193	152
89	550	2559	1089	4945	1087	4952	1077	4890	1059	4799	1395	6383	1357
23	119	549	201	913	217	983	205	933	213	967	251	1147	266

ISCHARGES

TRIBUTARY STORM				10-YEAR DESIGN TRIBUTARY STORM							
CONCEPT C		CONCEPT D		CONCEPT A		CONCEPT B		CONCEPT C		CONCEPT D	
Volume (Ac.Ft.)	Peak (C.F.S.)	Volume (Ac.Ft.)	Peak (C.F.S.)	Volume (Ac.Ft.)	Peak (C.F.S.)	Volume (Ac.Ft.)	Peak (C.F.S.)	Volume (Ac.Ft.)	Peak (C.F.S.)	Volume (Ac.Ft.)	Peak (C.F.S.)
908	2656	1461	4278	1895	5611	1816	5364	1154	3428	1895	5611
1402	5472	1761	6877	2353	9300	1839	7263	1771	6980	2268	8919
42	219	184	925	424	2158	-	-	56	294	245	1243
131	747	114	652	119	696	149	860	169	972	149	863
14	55	14	55	18	75	18	75	18	75	18	75
16	136	11	92	15	130	-	-	21	181	14	120
110	581	197	1057	538	2917	-	-	141	752	257	1399
680	3617	718	3844	938	5089	476	2549	879	4750	938	5089
703	3470	703	3470	900	4506	900	4506	900	4506	900	4506
807	3765	920	4307	1022	4806	1135	5351	1027	4832	1135	5351
27	105	304	1144	726	2784	-	-	33	132	405	1539
305	1296	467	1990	386	1654	147	606	391	1672	607	2617
314	2411	293	2227	335	2590	325	2515	403	3138	379	2935
516	2639	516	2639	662	3417	662	3417	662	3417	662	3417
551	2130	507	1960	712	2784	712	2784	712	2784	663	2583
1159	4666	1177	4755	1680	6839	1620	6621	1494	6076	1522	6200
-	-	92	676	142	1055	5	34	-	-	123	912
-	-	69	439	104	671	-	-	-	-	92	592
-	-	299	1024	383	1317	-	-	-	-	399	1374
-	-	-	-	823	2954	30	108	-	-	-	-
-	-	-	-	69	256	-	-	-	-	-	-
156	548	1050	3709	1439	5133	55	209	206	728	1400	4990
204	1020	226	1126	312	1577	49	246	272	1380	301	1523
18	108	207	1264	192	1184	-	-	23	138	276	1697
-	-	292	1499	512	2659	-	-	-	-	389	2021
163	878	420	2244	606	3275	107	575	213	1149	553	2993
625	2415	619	2401	827	3229	831	3223	786	3052	793	3078
510	2133	513	2149	600	2530	605	2558	641	2697	640	2699
68	343	299	1496	1305	6595	40	211	89	454	399	2013
348	1976	354	2019	401	2312	442	2542	438	2510	442	2542
552	2353	546	2334	698	3012	152	654	698	3012	728	3147
732	3462	770	3652	980	4696	661	2280	947	4545	992	4753
919	4016	1099	4794	1572	6915	553	2423	1204	5302	1463	6434
-	-	-	-	-	-	508	2585	-	-	-	-
-	-	-	-	-	-	334	1703	-	-	-	-
-	-	-	-	-	-	342	1744	-	-	-	-
141	1164	230	1894	214	1784	214	1784	177	1573	295	2468
97	786	107	877	93	777	132	1105	122	1021	136	1138
438	3605	516	4222	681	5688	825	6883	527	4396	617	5155
188	1324	276	1947	303	2174	390	2796	243	1738	358	2565
71	588	73	602	89	745	89	745	89	745	91	758
181	1489	171	1410	231	1922	228	1900	225	1878	216	1800
26	203	27	223	39	321	36	301	32	268	35	291
[illegible]	1583	364	3004	424	3530	387	3223	229	1916	438	3659
-	-	-	-	-	-	50	360	-	-	-	-
[illegible]	1174	584	3158	550	2988	270	1469	280	1526	768	4189
-	-	-	-	-	-	119	850	-	-	-	-
[illegible]	1416	173	1227	252	1809	458	3285	252	1416	214	1531
[illegible]	231	32	231	42	306	152	1084	42	306	42	306
-	-	-	-	-	-	292	2435	-	-	-	-
[illegible]	684	97	684	121	862	307	2202	121	862	121	862
[illegible]	[illegible]	539	3833	606	4335	536	3826	320	2716	670	4783
-	-	-	-	-	-	73	612	-	-	-	-
[illegible]	[illegible]	97	614	153	1098	173	1238	153	1098	111	795
[illegible]	[illegible]	[illegible]	1100	146	523	-	-	146	523	411	1476
[illegible]	-	354	1262	-	-	-	-	-	-	472	1697
-	-	-	-	-	-	284	1441	-	-	-	-
-	-	-	-	-	-	342	1744	-	-	-	-
[illegible]	[illegible]	18	145	143	1193	152	1275	143	1193	22	184
[illegible]	[illegible]	[illegible]	4799	1395	6383	1357	6210	1354	6186	1346	6188
[illegible]	[illegible]	[illegible]	967	251	1147	266	1219	255	1176	264	1204

3

TABULATION OF DATA CORRESPONDING TO ENVELOPING CURVES
OF ACCUMULATIVE RAINFALL-DURATION-FREQUENCY RELATIONS

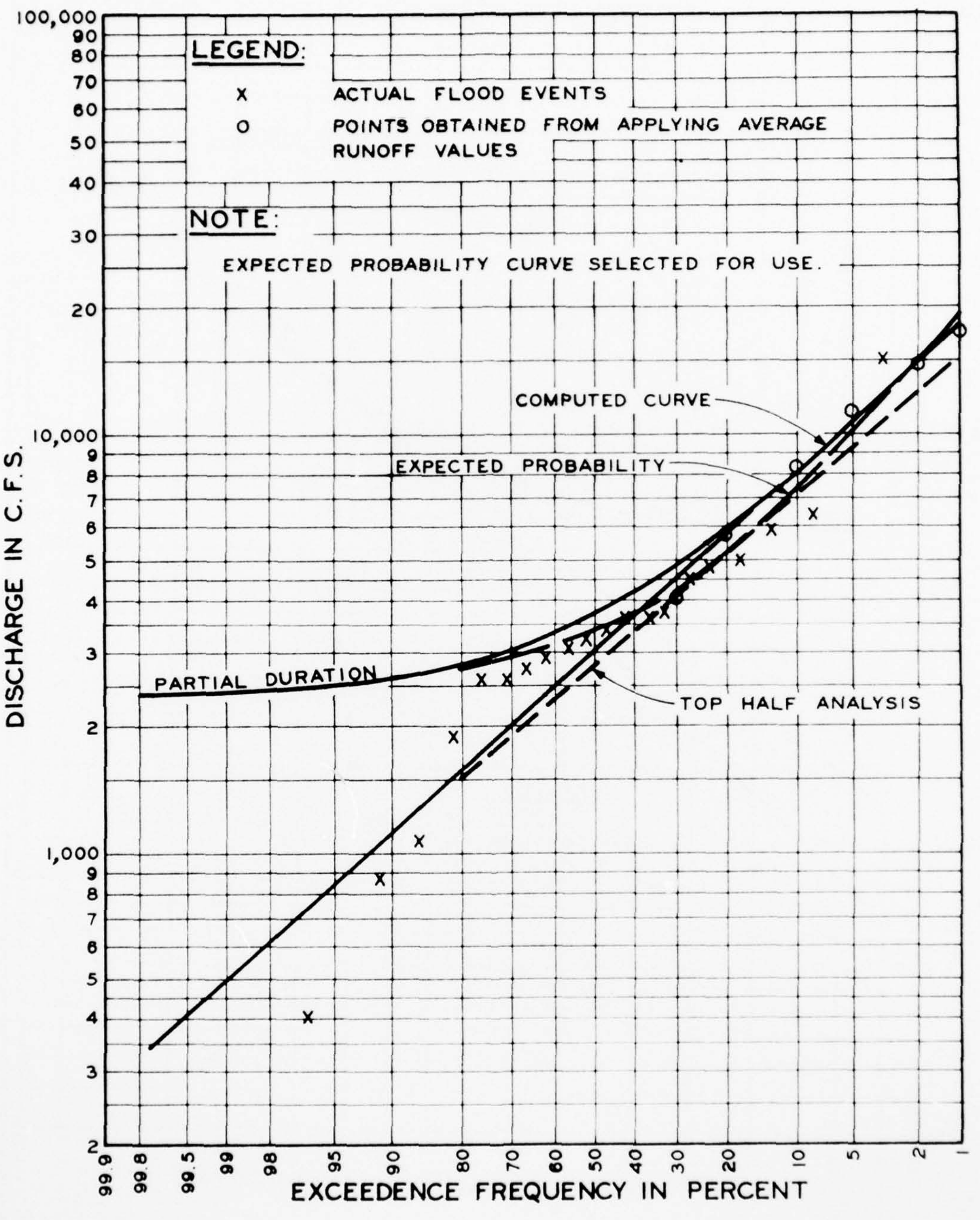
Line Ref.	Maximum Rainfall Duration In Hours	(1) RAINFALL IN INCHES DEPTH CORRESPONDING TO VARIOUS AVERAGE FREQUENCIES AND DURATIONS IN HOURS — Average Exceedence Frequency Interval, in Years: 1	2	5	10	25	50	100
Col. 1	2	3	4	5	6	7	8	9
(a)	Maximum Accumulation of Rainfall in Period Designated Column 2							
1	1	1.35	1.62	2.11	2.47	2.86	3.21	3.60
2	2	1.55	1.86	2.45	2.84	3.30	3.70	4.15
3	3	1.68	2.04	2.64	3.07	3.54	3.97	4.46
4	4	1.77	2.16	2.80	3.24	3.72	4.20	4.76
5	5	1.85	2.26	2.94	3.40	3.90	4.40	4.98
6	6	1.92	2.35	3.07	3.55	4.06	4.56	5.15
7	12	2.20	2.70	3.50	4.08	4.70	5.30	5.95
8	18	2.38	2.90	3.75	4.38	5.02	5.65	6.32
9	1-Day 24	2.52	3.05	3.95	4.60	5.28	5.98	6.67
10	2-Day 48	2.88	3.57	4.54	5.20	6.10	6.82	7.65
11	3-Day 72	3.10	3.83	4.90	5.69	6.60	7.34	8.20
12	4-Day 96	3.30	4.08	5.18	6.05	7.02	7.82	8.70
	7-Day 168	4.00	4.80	6.00	6.90	8.00	8.90	9.80
(b)	Rainfall by 1-Hour Increments During Maximum 6-Hour Accumulation							
13	0-1	1.35	1.62	2.11	2.47	2.86	3.21	3.60
14	1-2	0.20	0.24	0.34	0.37	0.44	0.49	0.55
15	2-3	0.13	0.18	0.19	0.23	0.24	0.27	0.31
16	3-4	0.09	0.12	0.16	0.19	0.18	0.23	0.30
17	4-5	0.08	0.10	0.14	0.16	0.18	0.20	0.22
18	5-6	0.07	0.09	0.13	0.15	0.16	0.16	0.17
(c)	Rainfall by 6-Hour Increments During Maximum 24-Hour Accumulation							
19	0-6	1.92	2.35	3.07	3.55	4.06	4.56	5.15
20	6-12	0.28	0.35	0.43	0.53	0.64	0.74	0.80
21	12-18	0.18	0.20	0.25	0.30	0.32	0.35	0.37
22	18-24	0.14	0.15	0.20	0.22	0.26	0.33	0.35
(d)	Rainfall by 24-Hour Increments During Maximum 96-Hour Accumulation							
23	0-24	2.52	3.05	3.95	4.60	5.28	5.98	6.67
24	24-48	0.36	0.52	0.59	0.60	0.82	0.84	0.98
25	48-72	0.26	0.26	0.35	0.49	0.50	0.52	0.55
26	72-96	0.20	0.25	0.28	0.36	0.42	0.48	0.50
	96-168	0.70	0.72	0.82	0.85	0.98	1.08	1.10

(1) Point rainfall values at Omaha, Nebraska, and Council Bluffs, Iowa.
Reference: U.S. Weather Bureau Technical Paper Nos. 40 and 49.

TABULATION OF DATA CORRESPONDING TO ENVELOPING CURVES
OF ACCUMULATIVE RAINFALL-DURATION-FREQUENCY RELATIONS

Line Ref.	Maximum Rainfall Duration In Hours	(1) RAINFALL IN INCHES DEPTH CORRESPONDING TO VARIOUS AVERAGE FREQUENCIES AND DURATIONS IN HOURS						
		Average Exceedence Frequency Interval, in Years						
		1	2	5	10	25	50	100
Col. 1	2	3	4	5	6	7	8	9
(a)	Maximum Accumulation of Rainfall in Period Designated Column 2							
1	1 (65%)	0.88	1.05	1.37	1.61	1.86	2.09	2.34
2	2 (72%)	1.12	1.34	1.76	2.05	2.38	2.66	2.99
3	3 (78%)	1.31	1.59	2.07	2.40	2.76	3.10	3.48
4	4 (80%)	1.42	1.73	2.25	2.60	2.99	3.36	3.81
5	5 (82%)	1.52	1.86	2.41	2.79	3.21	3.61	4.08
6	6 (84%)	1.61	1.97	2.57	2.97	3.41	3.83	4.33
7	12 (87%)	1.91	2.35	3.04	3.55	4.09	4.61	5.18
8	18 (90%)	2.14	2.61	3.38	3.94	4.52	5.08	5.69
9	1-Day 24 (91%)	2.29	2.78	3.60	4.19	4.80	5.44	6.07
10	2-Day 48 (93%)	2.68	3.32	4.22	4.84	5.67	6.34	7.12
11	3-Day 72 (94%)	2.91	3.60	4.60	5.35	6.20	6.90	7.71
12	4-Day 96 (95%)	3.14	3.88	4.92	5.75	6.67	7.43	8.27
	7-Day 168 (95%)	3.80	4.56	5.70	6.56	7.60	8.46	9.31
(b)	Rainfall by 1-Hour Increments During Maximum 6-Hour Accumulation							
13	0-1	0.88	1.05	1.37	1.61	1.86	2.09	2.34
14	1-2	0.24	0.29	0.39	0.44	0.52	0.57	0.65
15	2-3	0.19	0.25	0.31	0.35	0.38	0.44	0.49
16	3-4	0.11	0.14	0.18	0.20	0.23	0.26	0.33
17	4-5	0.10	0.13	0.16	0.19	0.22	0.25	0.27
18	5-6	0.09	0.11	0.16	0.18	0.20	0.22	0.25
(c)	Rainfall by 6-Hour Increments During Maximum 24-Hour Accumulation							
19	0-6	1.61	1.97	2.57	2.97	3.41	3.83	4.33
20	6-12	0.30	0.38	0.47	0.58	0.68	0.78	0.85
21	12-18	0.23	0.26	0.34	0.39	0.43	0.47	0.51
22	18-24	0.15	0.17	0.22	0.25	0.28	0.36	0.38
(d)	Rainfall by 24-Hour Increments During Maximum 96-Hour Accumulation							
23	0-24	2.29	2.78	3.60	4.19	4.80	5.44	6.07
24	24-48	0.39	0.54	0.62	0.65	0.87	0.90	1.05
25	48-72	0.23	0.28	0.38	0.51	0.53	0.56	0.59
26	72-96	0.23	0.28	0.32	0.40	0.47	0.53	0.56
	96-168	0.66	0.68	0.78	0.87	0.93	1.03	1.04

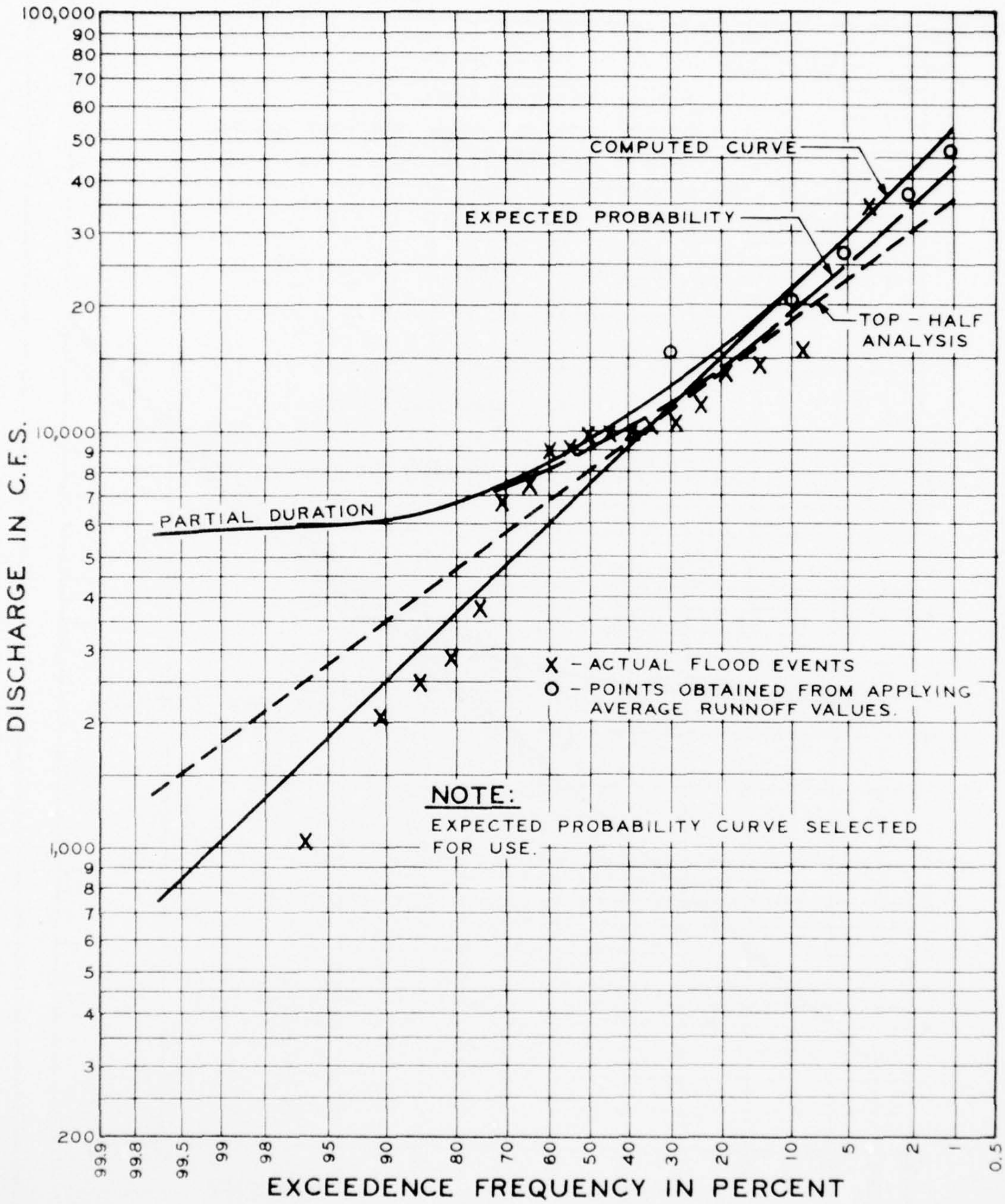
(1) Average rainfall amounts for a 400 square mile area in the vicinity of Omaha, Nebraska. Reference U.S. Weather Bureau Technical Paper Nos. 40 and 49.



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

LITTLE PAPILLION CREEK
AT IRVINGTON, NEBRASKA
DISCHARGE PROBABILITY
EXISTING CONDITIONS

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
PAPILLION CREEK AT
FORT CROOK, NEBRASKA
DISCHARGE PROBABILITY
EXISTING CONDITIONS

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

☆ U.S. GOVERNMENT PRINTING OFFICE 1972 768 646

PAPILLION CREEK TRIBUTARY
1-YEAR STORM
DESIGN RAINFALL AND RUNOFF FOR VARYING AMOUNTS OF IMPERVIOUS SURFACES

	0-1	1-2	2-3	3-4	4-5	5-6	0-6 HR	6-7	7-8	8-9	9-10	10-11	11-12	6-12 HR	12-13	13-14	14-15	15-16	16-17	17-18	12-18 HR	18-19	19-20	20-21	21-22	22-23	23-24	18-24 HR	24 HR
RAINFALL	0.02	0.02	0.02	0.02	0.03	0.03	0.14	0.04	0.04	0.05	0.05	0.05	0.05	0.28	0.07	0.08	0.09	0.13	1.35	0.20	1.92	0.03	0.03	0.03	0.03	0.03	0.03	0.18	2.52
[illegible] 0.19	0	0	0	0	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.01	0.01	0.02	0.02	0.26	0.04	0.36	0.01	0.01	0.01	0	0	0	0.03	[illegible]
0.37															0.02	0.03	0.03	0.04	0.50	0.08	0.70								
0.37															[illegible]	0.03	0.03	0.04	0.51	0.08	[illegible]								
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[illegible]															[illegible]	0.05	0.05	0.08	0.82	0.12	[illegible]								
[illegible]															[illegible]	0.06	0.07	0.10	1.02	0.15	[illegible]								
[illegible] 0.30	0.02	0.02	0.02	0.02	0.02	0.03	0.13	0.04	0.04	0.04	0.04	0.04	0.05	0.25	[illegible]	0.07	[illegible]	0.12	1.22	0.18	1.72	0.04	0.03	0.03	0.03	0.03	0.03	0.16	2.27

BEST AVAILABLE COPY

BEST AVAILABLE COPY

PAPILLION CREEK TRIBUTARY

5-YEAR [illegible]

DESIGN RAINFALL AND RUNOFF FOR VARYING AMOUNTS OF IMPERVIOUS SURFACES

	0-1	1-2	2-3	3-4	4-5	5-6	0-6 [illegible]	6-7	7-8	8-9	9-10	10-11	11-12	6-12 [illegible]	12-13	13-14	14-15	15-16	16-17	17-18	12-18 [illegible]	18-19	19-20	20-21	21-22	22-23	23-24	18-24 [illegible]	[illegible]
[illegible]	0.03	0.03	0.03	0.03	0.04	0.04	0.20	0.07	0.07	0.07	0.07	0.07	0.08	0.43	0.13	0.14	0.16	0.19	2.11	0.34	3.07	0.05	0.04	0.04	0.04	0.04	0.04	0.25	3.95
[illegible]	0.01	[illegible]	0.01	0.01	0.01	0.01	[illegible]	0.02	[illegible]	0.02	0.03	0.03	0.03	0.15	[illegible]	[illegible]	0.06	0.07	0.74	0.12	[illegible]	0.02	0.02	0.02	0.01	0.01	0.01	[illegible]	[illegible]
[illegible]															0.06	0.07	0.08	0.09	1.03	0.17	1.50								
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[illegible]															0.06	0.07	0.08	0.10	1.05	0.17	[illegible]								
[illegible]															0.07	0.07	0.08	0.10	1.06	0.17	[illegible]								
[illegible]															0.07	0.07	0.08	0.10	1.08	0.17	[illegible]								
[illegible]															0.07	0.07	0.08	0.10	1.09	0.18	[illegible]								
[illegible]															0.07	0.07	0.08	0.10	1.10	0.18	[illegible]								
[illegible]															0.07	0.07	0.08	0.10	1.11	0.18	[illegible]								
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[illegible]															0.07	0.08	0.09	0.10	1.15	0.19	[illegible]								
[illegible]															0.07	0.08	0.09	0.10	1.17	0.19	[illegible]								
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[illegible]															0.07	0.08	0.09	0.11	1.19	0.19	[illegible]								
[illegible]															0.07	0.08	0.09	0.11	1.20	0.20	[illegible]								
[illegible]															0.08	0.08	0.09	0.11	1.21	0.20	[illegible]								
[illegible]															0.08	0.08	0.09	0.11	1.22	0.20	[illegible]								
[illegible]															0.08	0.08	0.09	0.11	1.24	0.20	[illegible]								
[illegible]															0.08	0.08	0.10	0.11	1.25	0.20	[illegible]								
[illegible]															0.08	0.08	0.10	0.11	1.26	0.20	[illegible]								
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[illegible]	0.03	0.03	0.03	0.03	0.03	0.03	0.18	0.06	0.06	0.06	0.07	0.07	0.07	0.39	0.11	0.13	0.14	0.17	1.90	0.31	[illegible]	0.04	0.04	0.04	0.04	0.04	0.03	0.23	3.56

PAPILLION CREEK TRIBUTARY
10-YEAR STORM
DESIGN RAINFALL AND RUNOFF FOR VARYING AMOUNTS OF IMPERVIOUS SURFACES

	0-1	1-2	2-3	3-4	4-5	5-6	0-6 HR	6-7	7-8	8-9	9-10	10-11	11-12	6-12 HR	12-13	13-14	14-15	15-16	16-17	17-18	12-18 HR	18-19	19-20	20-21	21-22	22-23	23-24	18-24 HR	24 HR
[illegible]	[illegible]	[illegible]	[illegible]	0.04	0.04	0.04	0.22	0.08	0.09	0.09	0.09	0.09	0.09	0.53	[illegible]	0.16	0.17	0.23	2.47	0.37	2.55	0.05	0.05	0.05	0.05	0.05	0.05	[illegible]	4.60
[illegible] .45	0.01	0.01	0.01	[illegible]	0.02	[illegible]	0.09	0.04	0.04	0.04	0.04	0.04	0.04	0.24	[illegible]	0.07	0.08	0.10	1.11	0.17	[illegible]	0.03	0.03	0.02	0.02	0.02	0.02	[illegible]	[illegible]
[illegible]															0.08	0.09	0.10	0.13	1.39	0.21	[illegible]								
[illegible]															0.08	0.09	0.10	0.13	1.40	0.21	[illegible]								
[illegible]															0.09	0.09	0.10	0.13	1.41	0.21	2.03								
[illegible]															[illegible]	0.09	0.10	0.13	1.42	0.21	[illegible]								
[illegible]															[illegible]	9.09	0.10	0.13	1.43	0.22	[illegible]								
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[illegible]															[illegible]	0.13	0.14	0.19	2.00	0.30	[illegible]								
[illegible]	0.03	0.03	0.03	0.03	0.03	0.04	0.19	0.08	0.08	0.08	0.08	0.08	0.08	0.48	0.14	0.15	0.15	0.21	2.22	0.33	[illegible]	0.05	0.05	0.05	0.04	0.04	0.04	0.27	4.14

DATA INPUT FORM - "STORM" PROGRAM

DRAINAGE BASIN: LP-73 GROWTH CONCEPT(S): A

BASIN AREA (Acres): 2,186

STORM DATA*: Urban Stormwater Computations

NUMBER OF EVENTS: 3

EVENT DESCRIPTION: (1) 1 yr (2) 5 yr (3) 10 yr

LAND USE IN YEAR 2020: Average Basin Imperviousness = 35%

Type of Land Use	Area (Acres)	Percent of Land Area	Percent Impervious
Crop*	141	6.5	--
Industrial	217	10.0	75
Open*	88	4.0	5
Other Rural*	98	4.5	--
Residential	1,642	75.0	30

* Area not considered in the urban stormwater computations.

DATA INPUT FORM - "STORM" PROGRAM

DRAINAGE BASIN: LP-73 GROWTH CONCEPT(S): **B**

BASIN AREA (Acres): 2,186

STORM DATA*: Urban Stormwater Computations

NUMBER OF EVENTS: 3

EVENT DESCRIPTION: (1) 1 yr (2) 5 yr (3) 10 yr

LAND USE IN YEAR 2020: Average Basin Imperviousness = 36%

Type of Land Use	Area (Acres)	Percent of Land Area	Percent Impervious
Commercial	0	0	75
Industrial	55	2	75
Crops*	219	10	--
Other Rural*	153	7	--
Open*	18	1	5
Residential	1,741	80	35

* Area not considered in the urban stormwater computations

DATA INPUT FORM - "STORM" PROGRAM

DRAINAGE BASIN: LP-73   GROWTH CONCEPT(S): C

BASIN AREA (Acres): 2,186

STORM DATA*: Urban Stormwater Computations

NUMBER OF EVENTS: 3

EVENT DESCRIPTION: (1) 1 yr (2) 5 yr (3) 10 yr

LAND USE IN YEAR 2020: Average Basin Imperviousness = 39%

Type of Land Use	Area (Acres)	Percent of Land Area	Percent Impervious
Industrial	202	9.2	75
Open*	7	0.3	5
Residential	1,977	90.5	35

* Area not considered in the urban stormwater computations.

DATA INPUT FORM - "STORM" PROGRAM

DRAINAGE BASIN: LP-73 GROWTH CONCEPT(S): D

BASIN AREA (Acres): 2,186

STORM DATA*: Urban Stormwater Computations

NUMBER OF EVENTS: 3

EVENT DESCRIPTION: (1) 1 yr (2) 5 yr (3) 10 yr

LAND USE IN YEAR 2020: Average Basin Imperviousness = 34%

Type of Land Use	Area (Acres)	Percent of Land Area	Percent Impervious
Industrial	202	9	75
Open*	59	3	5
Residential	1,925	88	30

* Area not considered in the urban stormwater computations.

LP-76A	8,229	89.2	83.9	84.0	87.3	569	2053	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
LP-76B	1,497	82.8	84.7	85.0	85.2	110	513	122	563	112	523	119

NOTES: (1) Total Drainage Area - 1,337 acres.
(2) Total Drainage Area - 7,895 acres.
(3) Total Drainage Area - 7,786 acres.
(4) Total Drainage Area - 5,116 acres.

COMPUTATION SHEET

Corps of Engrs.	Sheet No. of
Project: Omaha-Council Bluffs Urban Study	Computed by: C.R.W. Date: 26 Aug 74
Subject: Area 73 of L. Papio U/S of Conf with Thomas Cr.	Checked by Date
Remarks:	Return to

TOTAL DRAINAGE AREA: 2,186 acres - 3.42 sq. mi.

BASIN DESIGNATION: LP-73

GROWTH CONCEPT(S): A

Total Drainage Basin Area (Acres)	Land Use Projection In Year	Number of Land Use Types	Total Area Impervious (Acres)	Total Percent of Area Impervious (Percent)
1,859	2020	2	656	35%

85% of Total Basin

STORM FREQUENCY	TIME IN HOURS 0-1	1-2	2-3	3-4	4-5	5-6
1-Year Rainfall No Area Size Adj.	0.07	0.08	0.09	0.13	1.35	0.20
Runoff From Impervious Area C = 0.90 IMP = 35%						
Runoff From Pervious Area C = 0.19 PER = 65%						
C_{comp} = 0.44 1-Year Composite Runoff	0.03	0.03	0.04	0.06	0.59	0.09
1-Year 6-Hour Runoff = 0.84 inches	1-Year 6-Hour Volume = 130.1 ac-ft					
5-Year Rainfall No Area Size Adj.	0.13	0.14	0.16	0.19	2.11	0.34
Runoff From Impervious Area C = 0.90 IMP = 35%						
Runoff From Pervious Area C = 0.35 PER = 65%						
C_{comp} = 0.54 5-Year Composite Runoff	0.07	0.08	0.09	0.10	1.15	0.18
5-Year 6-Hour Runoff = 1.67 inches	5-Year 6-Hour Volume = 252.6 ac-ft					
10-Year Rainfall No Area Size Adj.	0.15	0.16	0.17	0.23	2.47	0.37
Runoff From Impervious Area C = 0.90 IMP = 35%						
Runoff From Pervious Area C = 0.45 PER = 65%						
C_{comp} = 0.61 10-Year Composite Runoff	0.09	0.10	0.10	0.14	1.50	0.23
10-Year 6-Hour Runoff = 2.16 inches	10-Year 6-Hour Volume = 334.6 ac-ft					

MRD FORM 0486

COMPUTATION SHEET

Corps of Engrs.	Sheet No. of
Project: Omaha-Council Bluffs Urban Study	Computed by: C.R.W. Date: 26 Aug 74
Subject: Area 73 of L. Papio U/S of Conf with Thomas Cr.	Checked by / Date
Remarks:	Return to

TOTAL DRAINAGE AREA: 2,186 acres - 3.42 sq. mi.

BASIN DESIGNATION: LP-73

GROWTH CONCEPT(S): B

Total Drainage Basin Area (Acres)	Land Use Projection In Year	Number of Land Use Types	Total Area Impervious (Acres)	Total Percent of Area Impervious (Percent)
1,796	2020	2	650	36%

82% of Total Basin

STORM FREQUENCY	TIME IN HOURS 0-1	1-2	2-3	3-4	4-5	5-6
1-Year Rainfall No Area Size Adj.	0.07	0.08	0.09	0.13	1.35	0.20
Runoff From Impervious Area C = 0.90 IMP = 36%						
Runoff From Pervious Area C = 0.19 PER = 64%						
C_{comp} = 0.44 1-Year Composite Runoff	0.03	0.03	0.04	0.06	0.61	0.09
1-Year 6-Hour Runoff = 0.86 inches	1-Year 6-Hour Volume = 128.8 ac-ft					
5-Year Rainfall No Area Size Adj.	0.13	0.14	0.16	0.19	2.11	0.34
Runoff From Impervious Area C = 0.90 IMP = 36%						
Runoff From Pervious Area C = 0.35 PER = 64%						
C_{comp} = 0.55 5-Year Composite Runoff	0.07	0.08	0.09	0.10	1.15	0.19
5-Year 6-Hour Runoff = 1.68 inches	5-Year 6-Hour Volume = 251.3 ac-ft					
10-Year Rainfall No Area Size Adj.	0.15	0.16	0.17	0.23	2.47	0.37
Runoff From Impervious Area C = 0.90 IMP = 36%						
Runoff From Pervious Area C = 0.45 PER = 64%						
C_{comp} = 0.61 10-Year Composite Runoff	0.09	0.10	0.10	0.14	1.51	0.23
10-Year 6-Hour Runoff = 2.17 inches	10-Year 6-Hour Volume = 324.7 ac-ft					

MRD FORM 0185

AD-A041 929 ARMY ENGINEER DISTRICT OMAHA NEBR F/G 8/6
WATER AND RELATED LAND RESOURCES MANAGEMENT STUDY. VOLUME V. SU--ETC(U)
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2 OF 2
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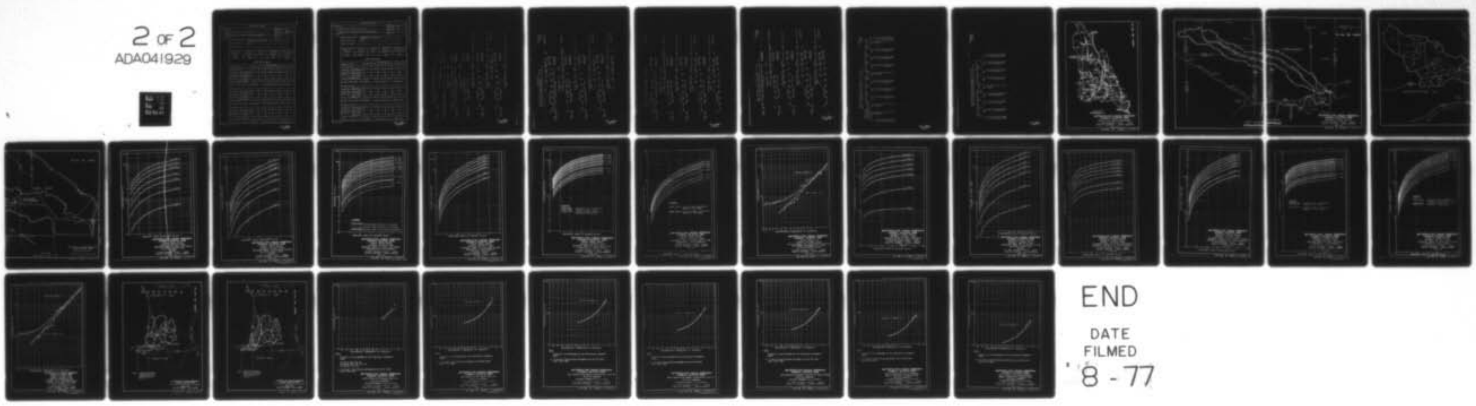

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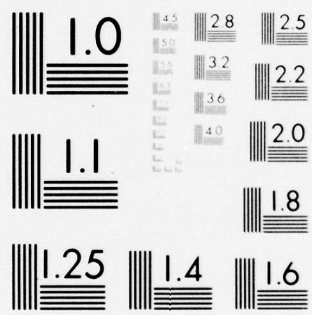

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

COMPUTATION SHEET

Corps of Engrs.	Sheet No. of
Project: Omaha-Council Bluffs Urban Study	Computed by: C.R.W. Date: 26 Aug 74
Subject: Area 73 of L. Papio U/S of Conf. with Thomas Cr.	Checked by / Date
Remarks:	Return to

TOTAL DRAINAGE AREA: 2,186 acres - 3.42 sq. mi.

BASIN DESIGNATION: LP-73

GROWTH CONCEPT(S): C

Total Drainage Basin Area (Acres)	Land Use Projection In Year	Number of Land Use Types	Total Area Impervious (Acres)	Total Percent of Area Impervious (Percent)
2,179	2020	2	844	39%

99.7% of Total Basin

STORM FREQUENCY	TIME IN HOURS 0-1	1-2	2-3	3-4	4-5	5-6
1-Year Rainfall No Area Size Adj.	0.07	0.08	0.09	0.13	1.35	0.20
Runoff From Impervious Area C = 0.90 IMP = 39%						
Runoff From Pervious Area C = 0.19 PER = 61%						
C_{comp} = 0.47 1-Year Composite Runoff	0.03	0.04	0.04	0.06	0.63	0.09
1-Year 6-Hour Runoff = 0.89 inches	1-Year 6-Hour Volume = 161.6 ac-ft					
5-Year Rainfall No Area Size Adj.	0.13	0.14	0.16	0.19	2.11	0.34
Runoff From Impervious Area C = 0.90 IMP = 39%						
Runoff From Pervious Area C = 0.35 PER = 61%						
C_{comp} = 0.56 5-Year Composite Runoff	0.07	0.08	0.09	0.11	1.19	0.19
5-Year 6-Hour Runoff = 1.73 inches	5-Year 6-Hour Volume = 314.2 ac-ft					
10-Year Rainfall No Area Size Adj.	0.15	0.16	0.17	0.23	2.47	0.37
Runoff From Impervious Area C = 0.90 IMP = 39%						
Runoff From Pervious Area C = 0.45 PER = 61%						
C_{comp} = 0.63 10-Year Composite Runoff	0.09	0.10	0.11	0.14	1.55	0.23
10-Year 6-Hour Runoff = 2.22 inches	10-Year 6-Hour Volume = 403.1 ac-ft					

MRD FORM 0486

COMPUTATION SHEET

Corps of Engrs.	Sheet No. of
Project: Omaha-Council Bluffs Urban Study	Computed by: C.R.W. Date
Subject: **Area 73 of L. Papio U/S of Conf with Thomas Cr**	Checked by / Date
Remarks:	Return to

TOTAL DRAINAGE AREA: **2,186 acres - 3.42 sq. mi.**

BASIN DESIGNATION: LP-73

GROWTH CONCEPT(S): D

Total Drainage Basin Area (Acres)	Land Use Projection In Year	Number of Land Use Types	Total Area Impervious (Acres)	Total Percent of Area Impervious (Percent)
2,127	2020	2	730	34%

97% of Total Basin

STORM FREQUENCY	TIME IN HOURS 0-1	1-2	2-3	3-4	4-5	5-6
1-Year Rainfall No Area Size Adj.	0.07	0.08	0.09	0.13	1.35	0.20
Runoff From Impervious Area C = 0.90 IMP = 34%						
Runoff From Pervious Area C = 0.19 PER = 66%						
C_{comp} = 0.43 1-Year Composite Runoff	0.03	0.03	0.04	0.06	0.58	0.09
1-Year 6-Hour Runoff = 0.83 inches	1-Year 6-Hour Volume = 147.2 ac-ft					
5-Year Rainfall No Area Size Adj.	0.13	0.14	0.16	0.19	2.11	0.34
Runoff From Impervious Area C = 0.90 IMP = 34%						
Runoff From Pervious Area C = 0.35 PER = 66%						
C_{comp} = 0.54 5-Year Composite Runoff	0.07	0.08	0.09	0.10	1.13	0.18
5-Year 6-Hour Runoff = 1.65 inches	5-Year 6-Hour Volume = 292.5 ac-ft					
10-Year Rainfall No Area Size Adj.	0.15	0.16	0.17	0.23	2.47	0.37
Runoff From Impervious Area C = 0.90 IMP = 34%						
Runoff From Pervious Area C = 0.45 PER = 66%						
C_{comp} = 0.60 10-Year Composite Runoff	0.09	0.10	0.10	0.14	1.49	0.22
10-Year 6-Hour Runoff = 2.14 inches	10-Year 6-Hour Volume = 379.2 ac-ft					

MRD FORM 0485

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                    OMAHA URBAN STUDY - LAND USE PROJECTION IN YEAR 2020                              PROGRAM H-062
                    LP-73     D.A. 2181 ACRES - 3.42 SQ MI                                                  06/26/74
                    AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE                               12:19.2

HYDRO      100 AREA 73   UNITGRAPH                                          500-HOURLIES

                                    100 AREA 73   UNITGRAPH                                                      500-HOURLIES
                                          0.     150.     880.    1990.    1200.    200.     100.

RUNOFF     100 AREA 73   UNITGRAPH                                          500-HOURLIES
   RESULT  101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE   500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =     1.0000)
                                      1.0000

           101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE   500-HOURLIES
                0.     150.    880.    1990.    1200.    200.    100.

RUNOFF     101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE   500-HOURLIES
   RESULT  102          *A*      85 PCT OF TOTAL AREA                       500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =     0.8500)
                                      0.8500

           102          *A*      85 PCT OF TOTAL AREA                       500-HOURLIES
                0.    127.    748.    1691.    1020.    170.     85.

RUNOFF     102          *A*      85 PCT OF TOTAL AREA                       500-HOURLIES
   RESULT  103          1-YEAR RUNOFF                                       500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =     0.8400)
                                      0.0300  0.0000  0.0300  0.0000  0.0400  0.0000  0.0600  0.0000  0.5900  0.0000
                                      0.0900

           103          1-YEAR RUNOFF                                       500-HOURLIES
                0.      4.     22.     55.     53.     61.     63.     80.     88.    184.
              506.   1020.    674.    253.    142.     15.      8.

RUNOFF     102          *A*      85 PCT OF TOTAL AREA                       500-HOURLIES
   RESULT  104          5-YEAR RUNOFF                                       500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =     1.6700)
                                      0.0700  0.0000  0.0800  0.0000  0.0900  0.0000  0.1000  0.0000  1.1500  0.0000
                                      0.1800

                                    102         *A*      85 PCT OF TOTAL AREA                            500-HOURLIES
                                          0.    127.    748.    1691.    1020.    170.     85.

           104          5-YEAR RUNOFF                                       500-HOURLIES
                0.      9.     52.    129.    131.    159.    155.    179.    173.    331.
              970.   1985.   1316.    500.    281.     31.     15.

RUNOFF     102          *A*      85 PCT OF TOTAL AREA                       500-HOURLIES
   RESULT  105          10-YEAR RUNOFF                                      500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =     2.1600)
                                      0.0900  0.0000  0.1000  0.0000  0.1000  0.0000  0.1400  0.0000  1.5000  0.0000
                                      0.2300
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OMAHA URBAN STUDY - LAND USE PROJECTION IN YEAR 2020                                          PROGRAM H-062
LP-73      D.A. 2181 ACRES = 3.42 SQ MI                                                            08/28/74
AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE                                          12:19.3

                          102          *A*    85 PCT OF TOTAL AREA                            500-HOURLIES
                              0.    127.    748.   1691.   1020.    170.     85.

      105          10-YEAR RUNOFF                                      500-HOURLIES
            0.     11.     67.    165.    167.    197.    184.    204.    215.    445.
         1273.   2590.   1714.    644.    362.     39.     20.

RUNOFF    101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE     500-HOURLIES
  RESULT 102            *B*      82 PCT OF TOTAL AREA                        500-HOURLIES

                          RUNOFF CONSTANTS (SUM =      0.8200)
                            0.8200

                          101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE     500-HOURLIES
                              0.    150.    880.   1990.   1200.    200.    100.

      102               *B*      82 PCT OF TOTAL AREA                        500-HOURLIES
            0.    123.    722.   1632.    984.    164.     82.

RUNOFF    102           *B*      82 PCT OF TOTAL AREA                        500-HOURLIES
  RESULT 103            1-YEAR RUNOFF                                        500-HOURLIES

                          RUNOFF CONSTANTS (SUM =      0.8600)
                            0.2300  0.0000  0.0300  0.0000  0.0400  0.0000  0.0600  0.0000  0.6100  0.0000
                            0.0900

      103           1-YEAR RUNOFF                                      500-HOURLIES
            0.      4.     22.     53.     51.     59.     61.     78.     85.    179.
          502.   1016.    670.    247.    139.     15.      7.

RUNOFF    102           *B*      82 PCT OF TOTAL AREA                        500-HOURLIES
  RESULT 104            5-YEAR RUNOFF                                        500-HOURLIES

                          RUNOFF CONSTANTS (SUM =      1.6600)
                            0.0700  0.0000  0.0800  0.0000  0.0900  0.0000  0.1000  0.0000  1.1500  0.0000
                            0.1900

                          102          *B*     82 PCT OF TOTAL AREA                           500-HOURLIES
                              0.    123.    722.   1632.    984.    164.     82.

      104           5-YEAR RUNOFF                                      500-HOURLIES
            0.      9.     51.    124.    127.    153.    149.    172.    167.    319.
          935.   1916.   1277.    499.    281.     31.     16.

RUNOFF    102           *B*      82 PCT OF TOTAL AREA                        500-HOURLIES
  RESULT 105            10-YEAR RUNOFF                                       500-HOURLIES

                          RUNOFF CONSTANTS (SUM =      2.1700)
                            0.0900  0.0000  0.1000  0.0000  0.1000  0.0000  0.1400  0.0000  1.5100  0.0000
                            0.2300

                          102          *B*     82 PCT OF TOTAL AREA                           500-HOURLIES
                              0.    123.    722.   1632.    984.    164.     82.
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            OMAHA URBAN STUDY - LAND USE PROJECTION IN YEAR 2020                                          PROGRAM H-062
            LP-73     D.A. 2181 ACRES = 3.42 SQ MI                                                            06/28/74
            AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE                                         12:19.4

         105          10-YEAR RUNOFF                                              500-HOURLIES
              0.     11.     65.    159.    161.    190.    176.    197.    208.    431.
           1236.   2515.   1663.    623.    350.     38.     19.

RUNOFF   101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE           500-HOURLIES
  RESULT 102          *C*       99.7 PCT OF TOTAL AREA                            500-HOURLIES

                                   RUNOFF CONSTANTS (SUM =      0.9970)
                                    0.9970

                                   101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE     500-HOURLIES
                                        0.    150.    880.   1990.   1200.    200.    100.

         102          *C*       99.7 PCT OF TOTAL AREA                            500-HOURLIES
              0.    150.    877.   1984.   1196.    199.    100.

RUNOFF   102          *C*       99.7 PCT OF TOTAL AREA                            500-HOURLIES
  RESULT 103          1-YEAR RUNOFF                                               500-HOURLIES

                                   RUNOFF CONSTANTS (SUM =      0.8900)
                                    0.0300  0.0000  0.0400  0.0000  0.0400  0.0000  0.0600  0.0000  0.6300  0.0000
                                    0.0900

         103          1-YEAR RUNOFF                                               500-HOURLIES
              0.      4.     26.     66.     71.     91.     86.     96.    104.    221.
            629.   1275.    839.    304.    170.     18.      9.

RUNOFF   102          *C*       99.7 PCT OF TOTAL AREA                            500-HOURLIES
  RESULT 104          5-YEAR RUNOFF                                               500-HOURLIES

                                   RUNOFF CONSTANTS (SUM =      1.7300)
                                    0.0700  0.0000  0.0800  0.0000  0.0900  0.0000  0.1100  0.0000  1.1900  0.0000
                                    0.1900

                                   102          *C*       99.7 PCT OF TOTAL AREA                       500-HOURLIES
                                        0.    150.    877.   1984.   1196.    199.    100.

         104          5-YEAR RUNOFF                                               500-HOURLIES
              0.     10.     61.    151.    154.    186.    182.    211.    212.    414.
           1185.   2411.   1601.    614.    346.     38.     19.

RUNOFF   102          *C*       99.7 PCT OF TOTAL AREA                            500-HOURLIES
  RESULT 105          10-YEAR RUNOFF                                              500-HOURLIES

                                   RUNOFF CONSTANTS (SUM =      2.2200)
                                    0.0900  0.0000  0.1000  0.0000  0.1100  0.0000  0.1400  0.0000  1.5500  0.0000
                                    0.2300

                                   102          *C*       99.7 PCT OF TOTAL AREA                       500-HOURLIES
                                        0.    150.    877.   1984.   1196.    199.    100.

         105          10-YEAR RUNOFF                                              500-HOURLIES
              0.     13.     79.    194.    195.    233.    225.    259.    264.    532.
           1538.   3138.   2070.    765.    430.     46.     23.
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                    OMAHA URBAN STUDY - LAND USE PROJECTION IN YEAR 2020                                        PROGRAM H-062
                    LP-73      D.A. 2186 ACRES = 3.42 SQ MI                                                          08/28/74
                    AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE                                        12:19.6
RUNOFF    101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE       500-HOURLIES
   RESULT 102             *D*       97   PCT OF TOTAL AREA                     500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =      0.9700)
                                     0.9700

                                    101 AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE       500-HOURLIES
                                          0.     150.    880.   1990.   1200.    200.    100.

          102             *D*       97   PCT OF TOTAL AREA                     500-HOURLIES
               0.     145.    854.   1930.   1164.    194.     97.

RUNOFF    102             *D*       97   PCT OF TOTAL AREA                     500-HOURLIES
   RESULT 103             1-YEAR RUNOFF                                        500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =      0.8300)
                                     0.0300  0.0000  0.0300  0.0000  0.0400  0.0000  0.0600  0.0000  0.5800  0.0000
                                     0.0900

          103             1-YEAR RUNOFF                                        500-HOURLIES
               0.       4.     26.     62.     61.     70.     72.     92.    101.    208.
             569.    1144.    758.    286.    161.     17.      9.

RUNOFF    102             *D*       97   PCT OF TOTAL AREA                     500-HOURLIES
   RESULT 104             5-YEAR RUNOFF                                        500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =      1.6500)
                                     0.0700  0.0000  0.0800  0.0000  0.0900  0.0000  0.1000  0.0000  1.1300  0.0000
                                     0.1800

                                    102            *D*       97   PCT OF TOTAL AREA                   500-HOURLIES
                                          0.     145.    854.   1930.   1164.    194.     97.

          104             5-YEAR RUNOFF                                        500-HOURLIES
               0.      10.     60.    147.    150.    181.    177.    204.    198.    375.
            1090.    2227.   1479.    567.    319.     35.     17.

RUNOFF    102             *D*       97   PCT OF TOTAL AREA                     500-HOURLIES
   RESULT 105             10-YEAR RUNOFF                                       500-HOURLIES

                                    RUNOFF CONSTANTS (SUM =      2.1400)
                                     0.0900  0.0000  0.1000  0.0000  0.1000  0.0000  0.1400  0.0000  1.4900  0.0000
                                     0.2200

                                    102            *D*       97   PCT OF TOTAL AREA                   500-HOURLIES
                                          0.     145.    854.   1930.   1164.    194.     97.

          105             10-YEAR RUNOFF                                       500-HOURLIES
               0.      13.     77.    188.    190.    225.    210.    233.    246.    506.
            1445.    2935.   1936.    714.    401.     43.     21.

END
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OMAHA URBAN STUDY - LAND USE PROJECTION IN YEAR 2020
LP-73 D.A. 218L ACRES - 3.42 SQ MI
AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE

PROGRAM H-062
08/28/74
12:20.1

HOUR	AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE HYDRO 101	A 85 PCT OF TOTAL AREA HYDRO 102	1-YEAR RUNOFF HYDRO 103	5-YEAR RUNOFF HYDRO 104	10-YEAR RUNOFF HYDRO 105	B 82 PCT OF TOTAL AREA HYDRO 102	1-YEAR RUNOFF. HYDRO 103	5-YEAR RUNOFF HYDRO 104	10-YEAR RUNOFF HYDRO 105	C 99.7 PCT OF TOTAL AREA HYDRO 102	HOUR
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0
500	150.	127.	4.	9.	11.	123.	4.	9.	11.	150.	500
1000	880.	748.	22.	52.	67.	722.	22.	51.	65.	877.	1000
1500	1990.	1691.	55.	129.	165.	1632.	53.	124.	159.	1984.	1500
2000	1200.	1020.	53.	131.	167.	984.	51.	127.	161.	1196.	2000
2500	200.	170.	61.	159.	197.	164.	59.	153.	190.	199.	2500
3000	100.	85.	63.	155.	184.	82.	61.	149.	178.	100.	3000
3500	0.	0.	80.	179.	204.	0.	78.	172.	197.	0.	3500
4000	0.	0.	88.	173.	215.	0.	85.	167.	208.	0.	4000
4500	0.	0.	184.	331.	445.	0.	179.	319.	431.	0.	4500
5000	0.	0.	506.	970.	1273.	0.	502.	936.	1236.	0.	5000
5500	0.	0.	1020.	1985.	2590.	0.	1016.	1916.	2515.	0.	5500
6000	0.	0.	674.	1316.	1714.	0.	670.	1277.	1563.	0.	6000
6500	0.	0.	253.	500.	644.	0.	247.	499.	623.	0.	6500
7000	0.	0.	142.	281.	362.	0.	139.	281.	350.	0.	7000
7500	0.	0.	15.	31.	39.	0.	15.	31.	38.	0.	7500
8000	0.	0.	8.	15.	20.	0.	7.	16.	19.	0.	8000

OMAHA URBAN STUDY - LAND USE PROJECTION IN YEAR 2020
LP-73 D.A. 2181 ACRES - 3.42 SQ MI
AREA 73 OF L PAPIO U/S OF CONF THOMAS CR AT IRVINGTON GAGE

PROGRAM H-062
08/28/74
12:20.4

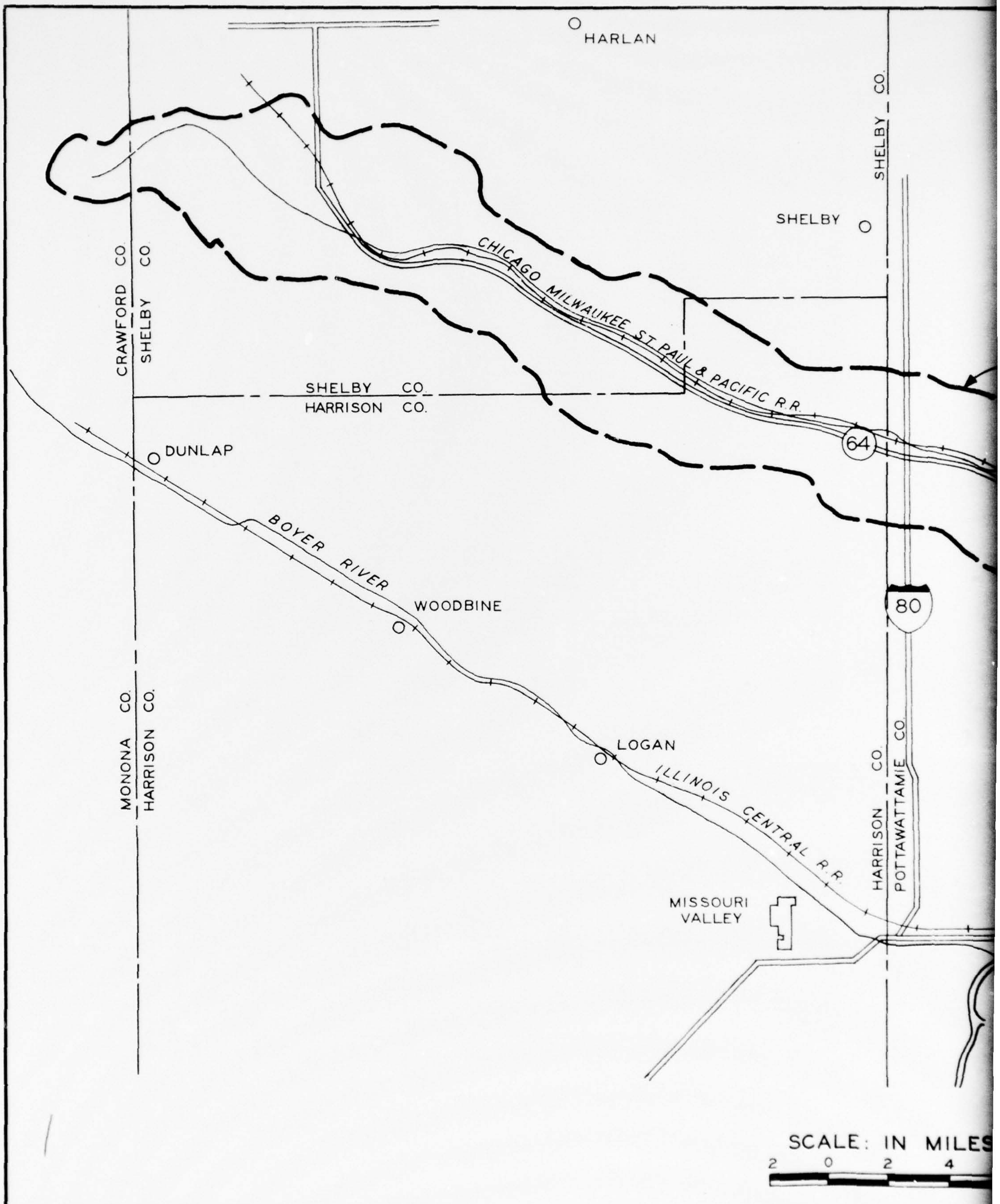
HOUR	1-YEAR RUNOFF HYDRO 103	5-YEAR RUNOFF HYDRO 104	10-YEAR RUNOFF HYDRO 105	D. 97 PCT OF TOTAL AREA HYDRO 102	1-YEAR RUNOFF HYDRO 103	5-YEAR RUNOFF HYDRO 104	10-YEAR RUNOFF HYDRO 105	HOUR
0	0.	0.	0.	0.	0.	0.	0.	0
500	4.	10.	13.	145.	4.	10.	13.	500
1000	26.	51.	79.	854.	26.	60.	77.	1000
1500	66.	151.	194.	1930.	62.	147.	188.	1500
2000	71.	154.	195.	1164.	61.	150.	190.	2000
2500	91.	186.	233.	194.	70.	181.	225.	2500
3000	86.	182.	225.	97.	72.	177.	210.	3000
3500	96.	211.	259.	0.	92.	204.	233.	3500
4000	104.	212.	264.	0.	101.	198.	246.	4000
4500	221.	414.	532.	0.	208.	175.	506.	4500
5000	629.	1185.	1538.	0.	569.	1090.	1445.	5000
5500	1275.	2411.	3138.	0.	1144.	2127.	2935.	5500
6000	839.	1601.	2070.	0.	758.	1479.	1936.	6000
6500	304.	614.	765.	0.	286.	567.	714.	6500
7000	170.	346.	430.	0.	161.	319.	401.	7000
7500	18.	38.	46.	0.	17.	35.	43.	7500
8000	9.	19.	23.	0.	9.	17.	21.	8000

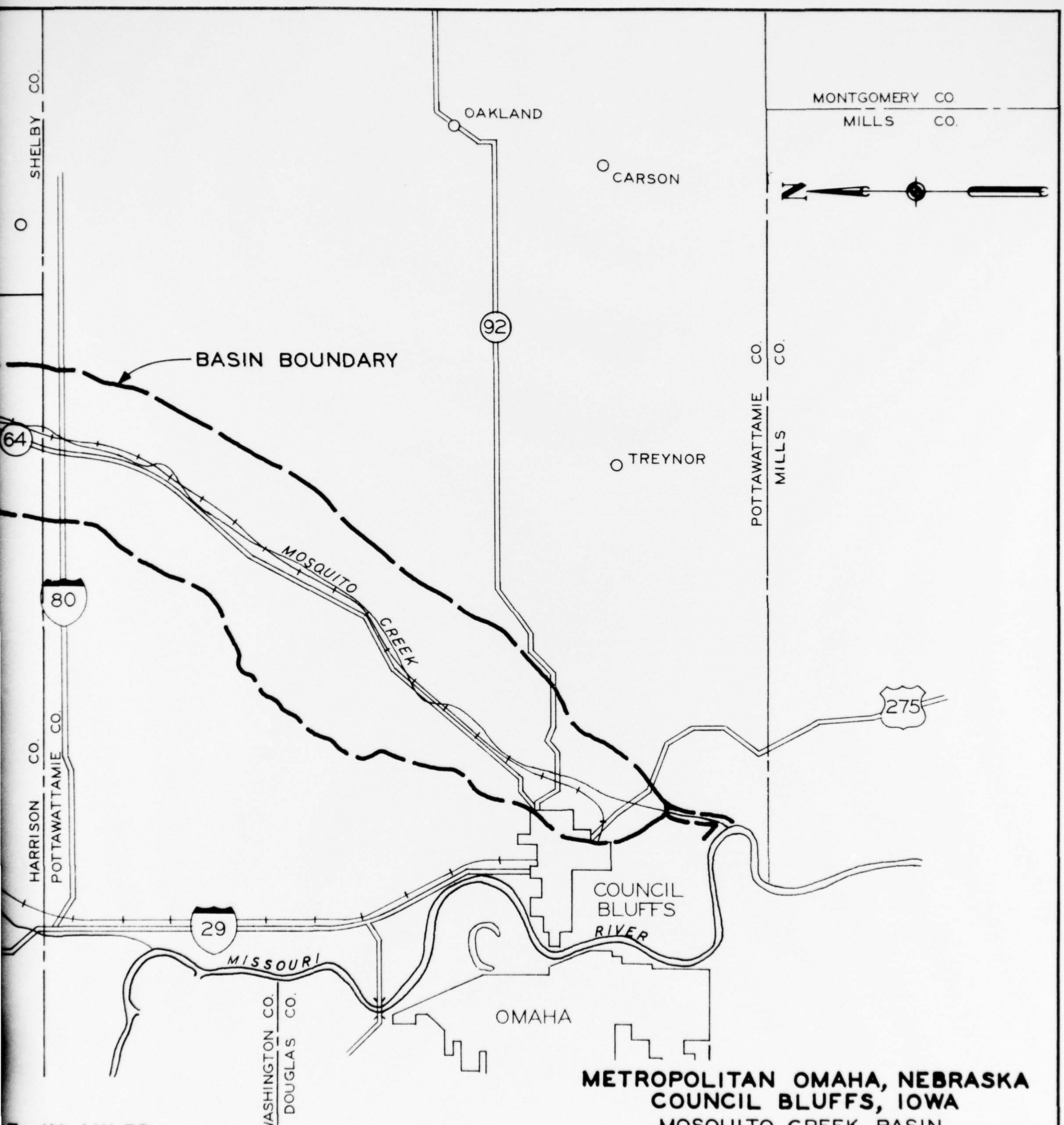
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

PAPILLION CREEK WATERSHED

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA

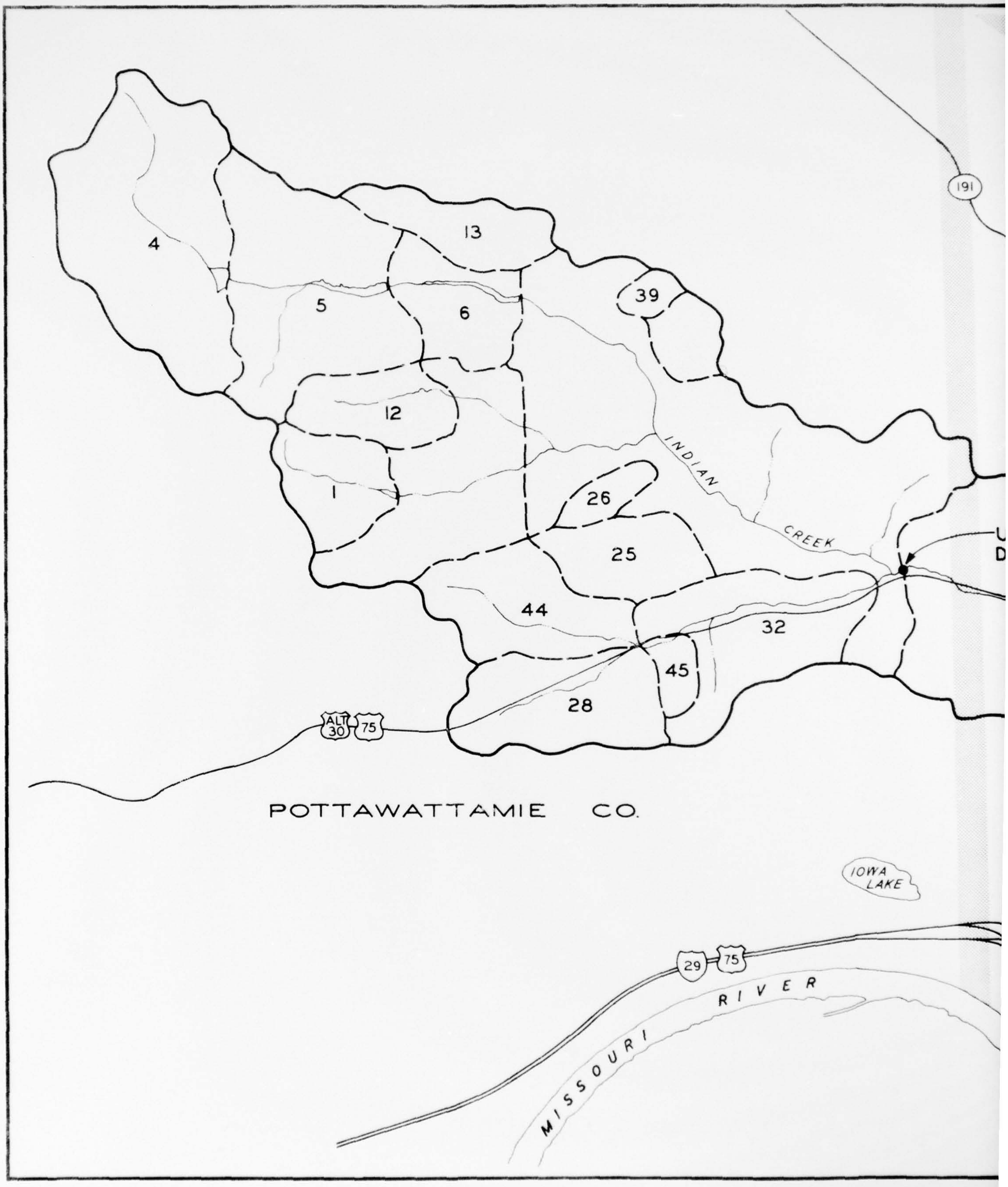
JUNE 1975


HARLAN
SHELBY CO.
SHELBY
CRAWFORD CO.
SHELBY CO.
CHICAGO MILWAUKEE ST. PAUL & PACIFIC R.R.
SHELBY CO.
HARRISON CO.
64
DUNLAP
BOYER RIVER
WOODBINE
80
MONONA CO.
HARRISON CO.
LOGAN
ILLINOIS CENTRAL R.R.
HARRISON CO.
POTTAWATTAMIE CO.
MISSOURI VALLEY
SCALE: IN MILES
2 0 2 4

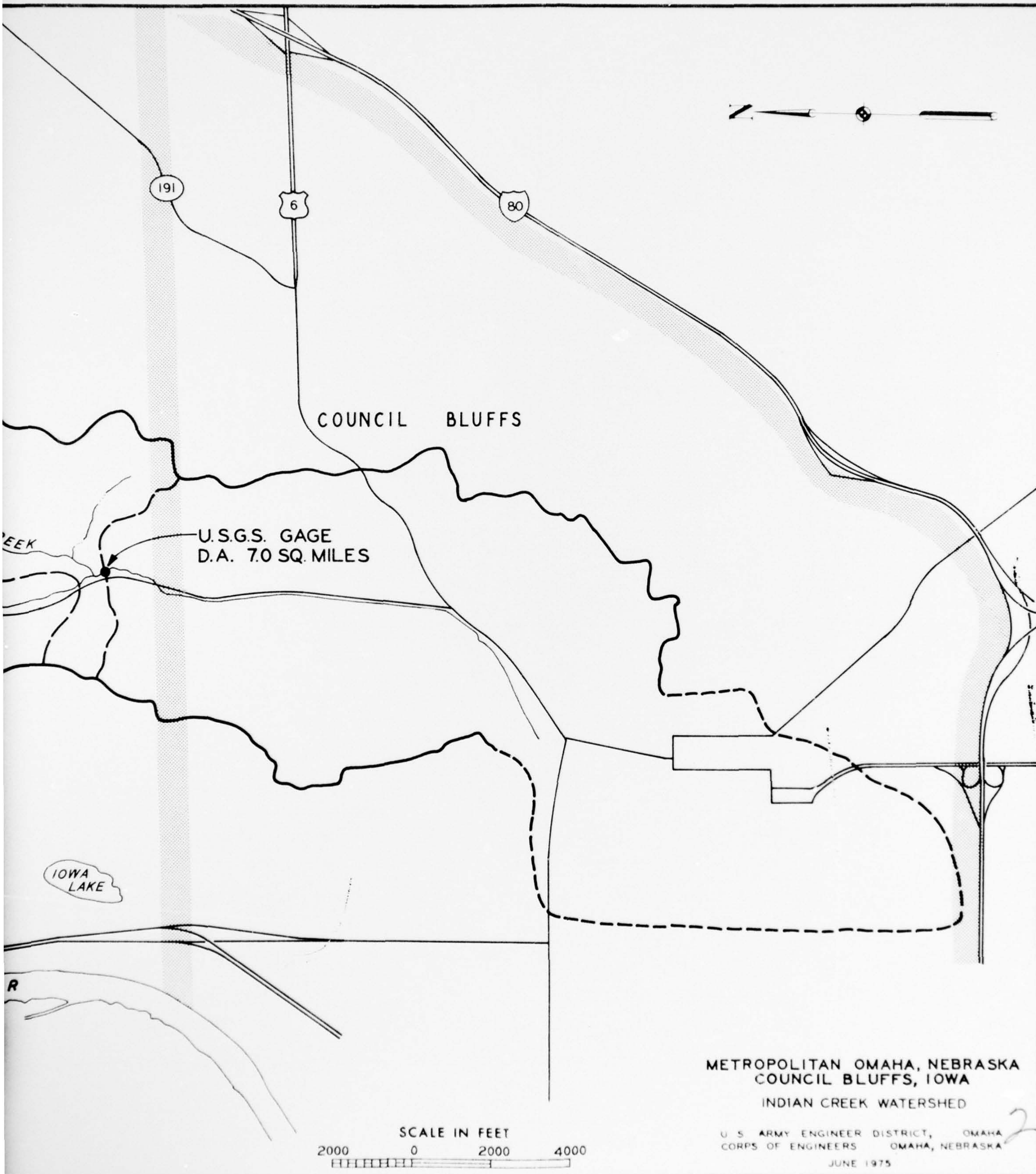


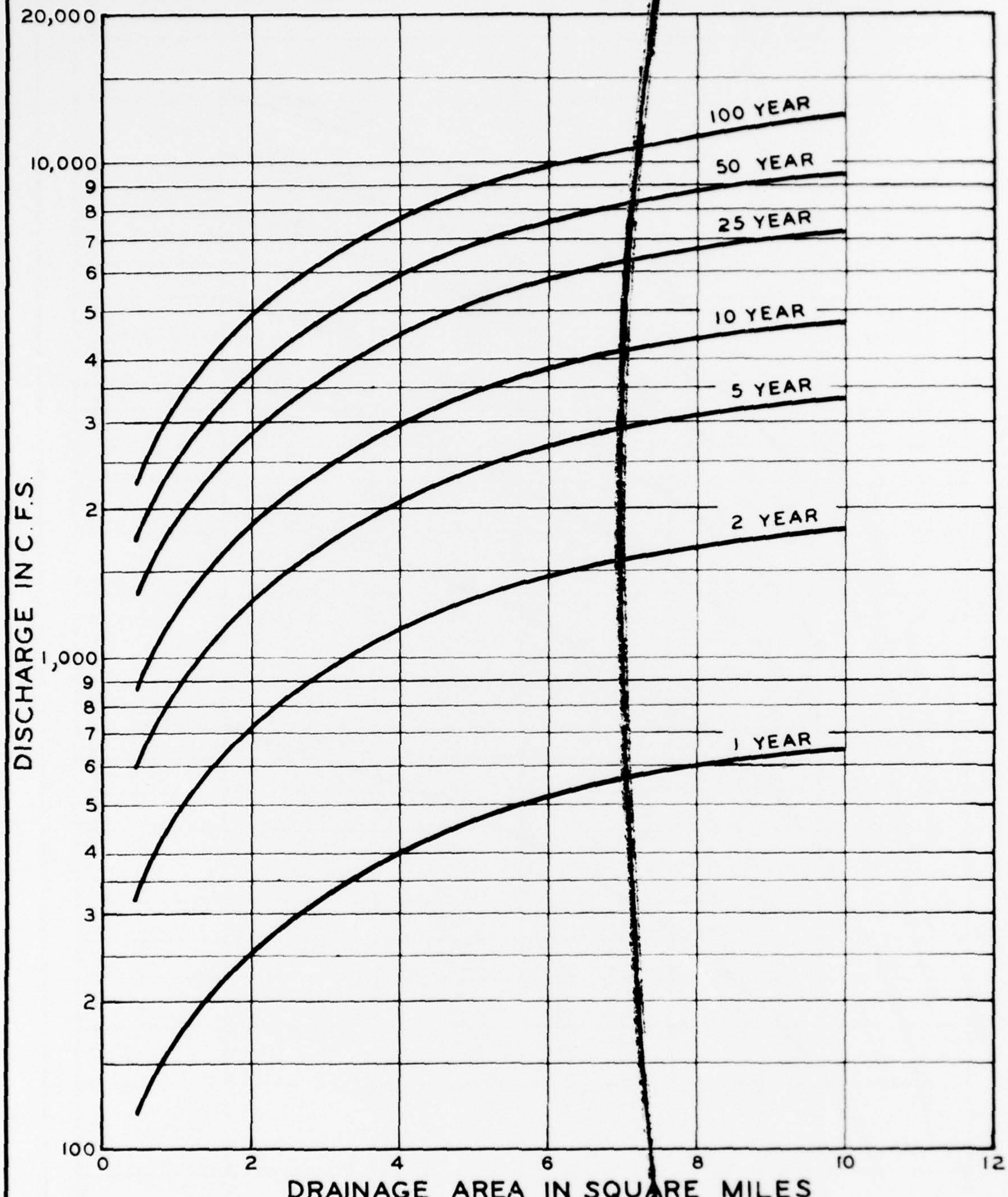
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
MOSQUITO CREEK BASIN
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

VOLUME V ANNEX C PLATE 57



191
4
13
5
6
39
12
1
26
INDIAN
CREEK
25
44
32
45
28
ALT 30
75
POTTAWATTAMIE CO.
IOWA LAKE
29
75
MISSOURI RIVER

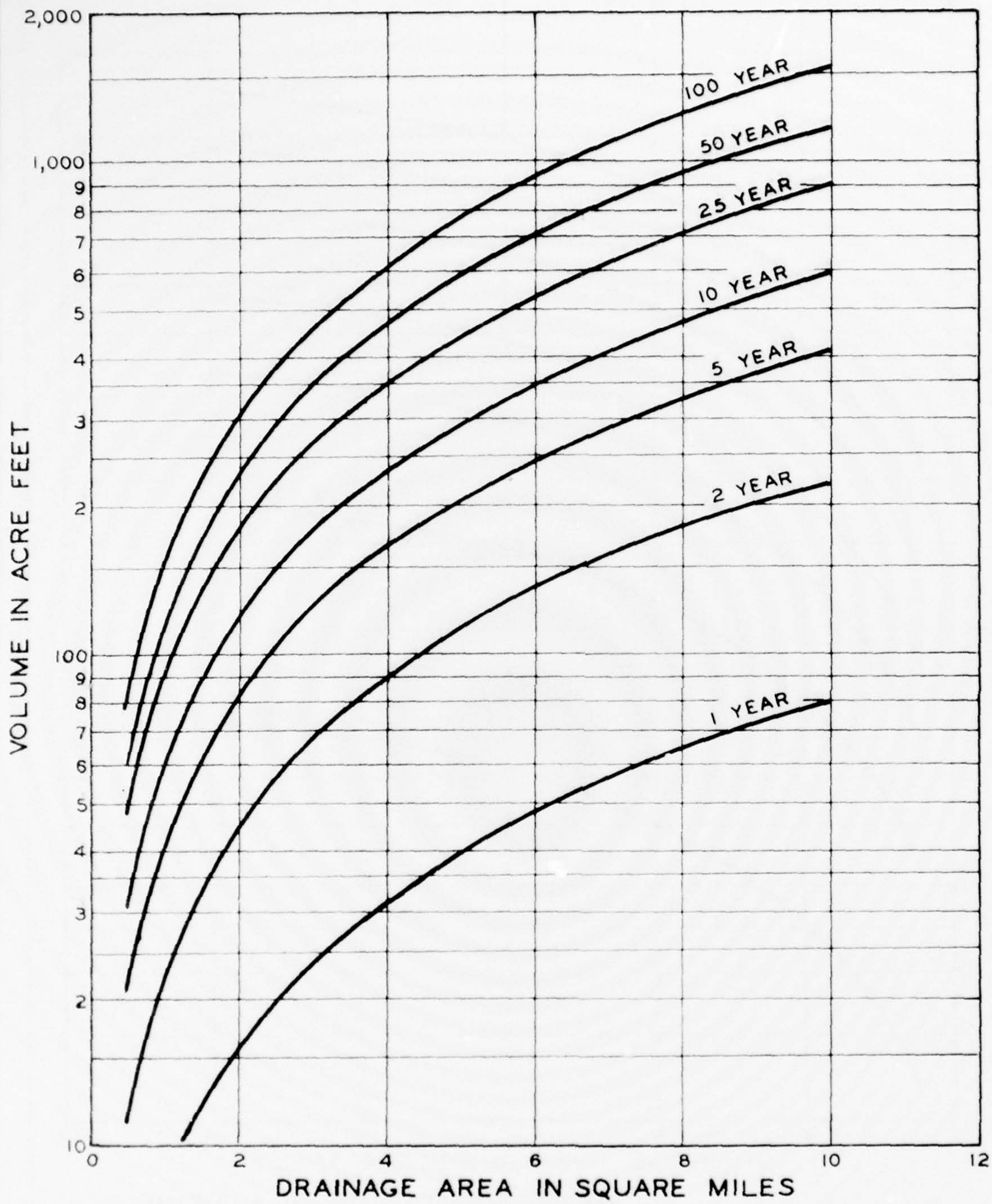

191
6
80
COUNCIL BLUFFS
U.S.G.S. GAGE
D.A. 7.0 SQ. MILES
IOWA LAKE
SCALE IN FEET
2000 0 2000 4000
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
INDIAN CREEK WATERSHED
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

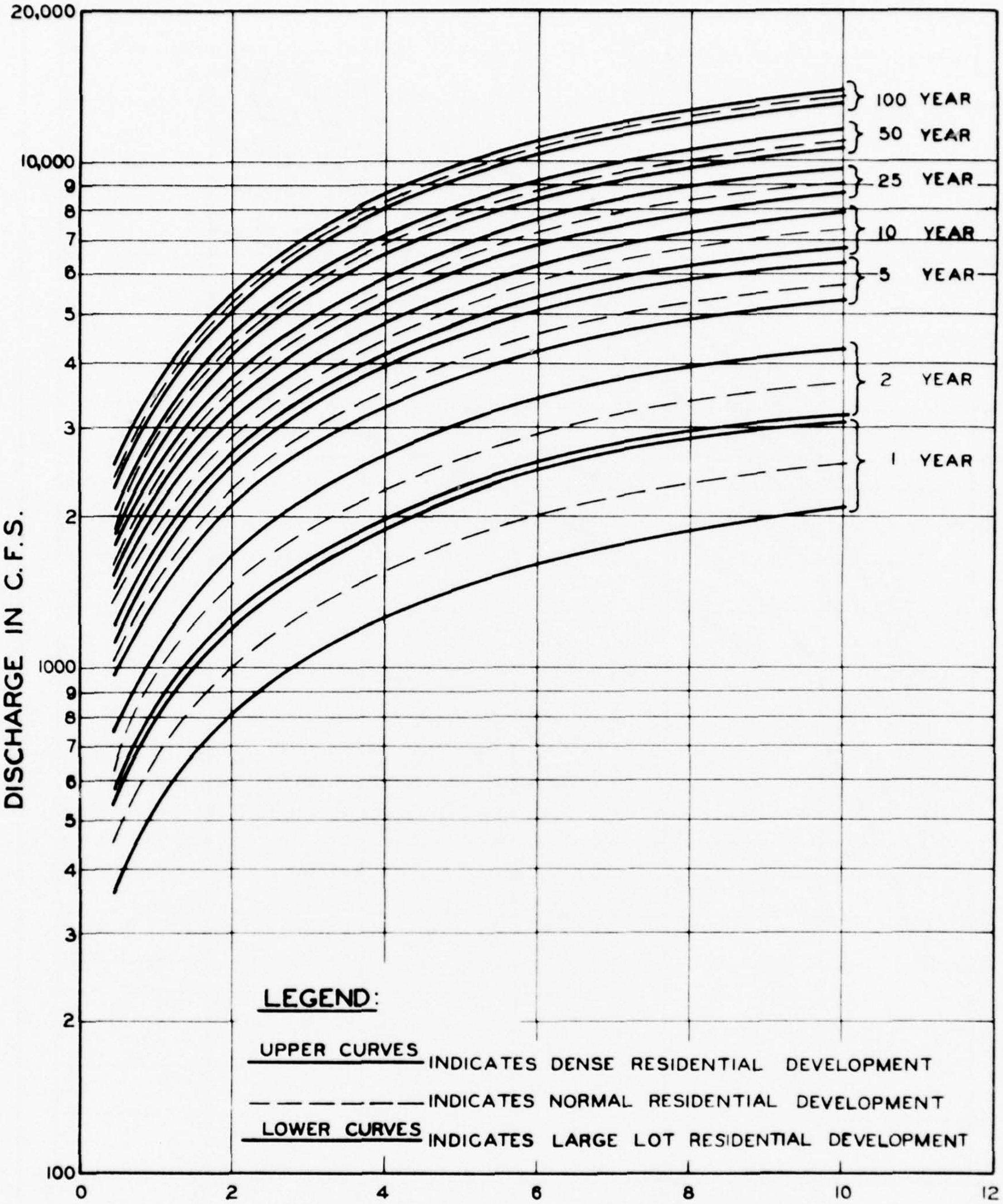
INDIAN CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. PEAK DISCHARGE
EXISTING CONDITIONS
RURAL

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



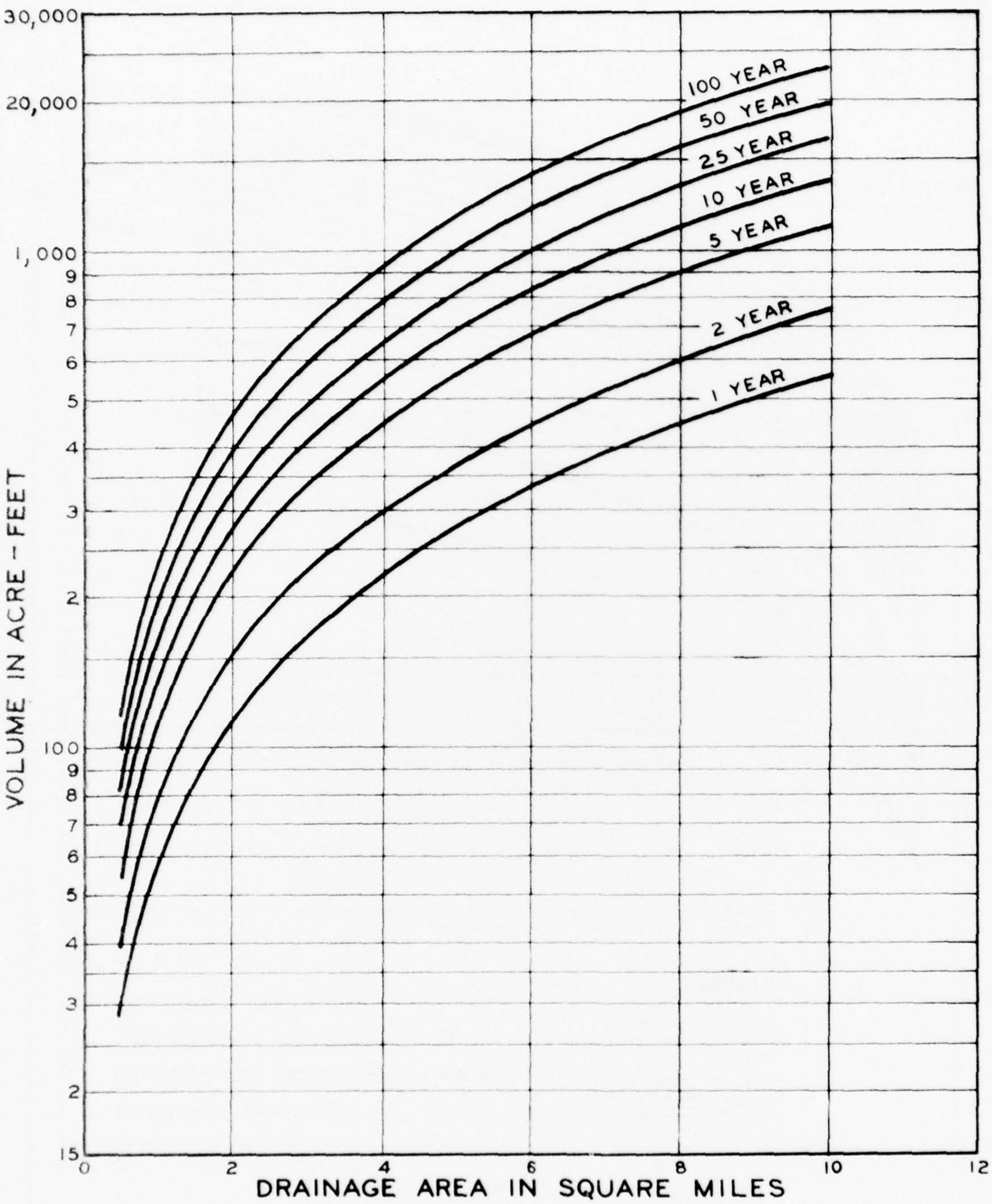
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
INDIAN CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. 24 HOUR VOLUME
EXISTING CONDITIONS
RURAL
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

☆ U.S. GOVERNMENT PRINTING OFFICE 1972 760 646



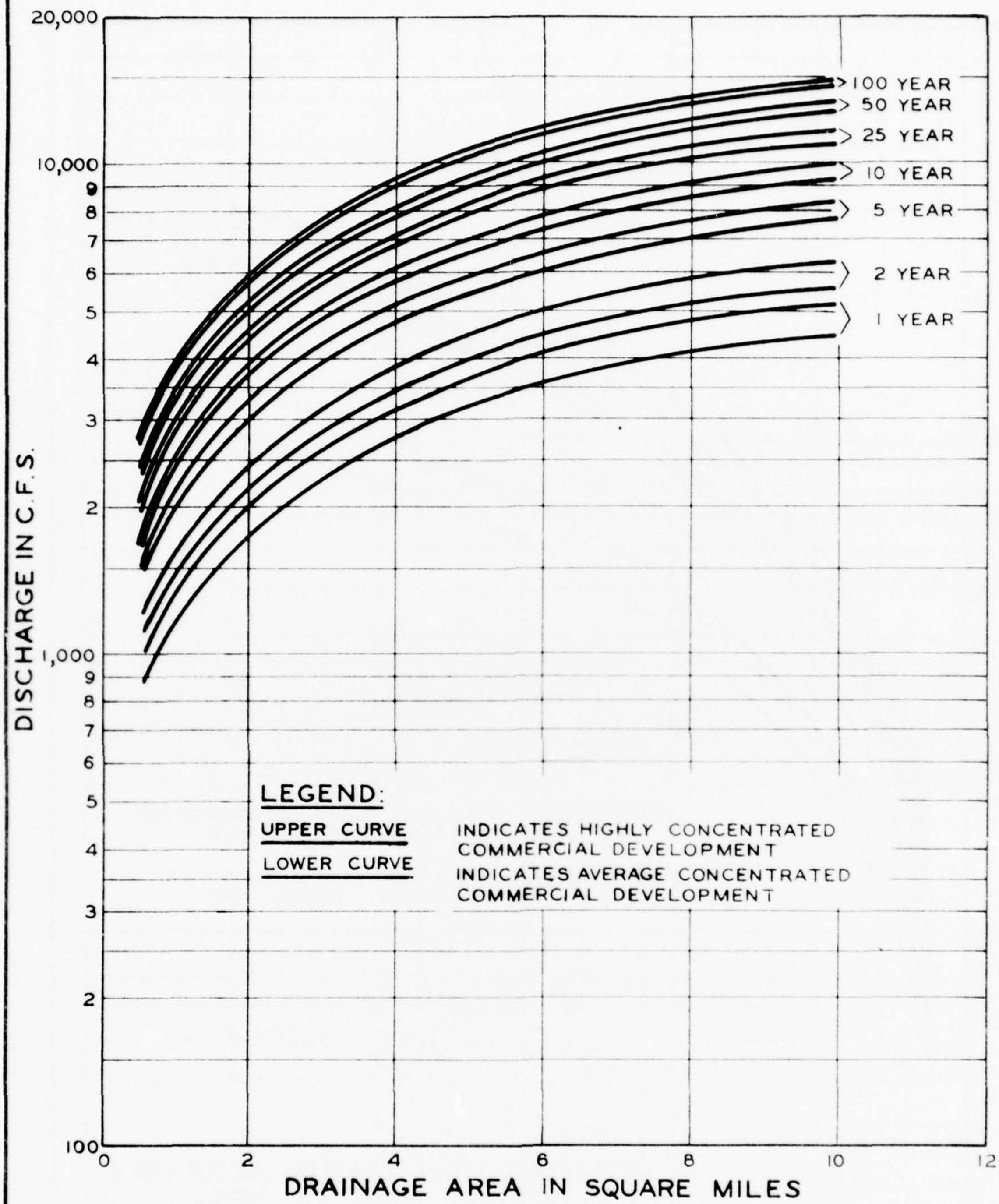
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
INDIAN CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. PEAK DISCHARGE
(RESIDENTIAL DEVELOPMENT)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



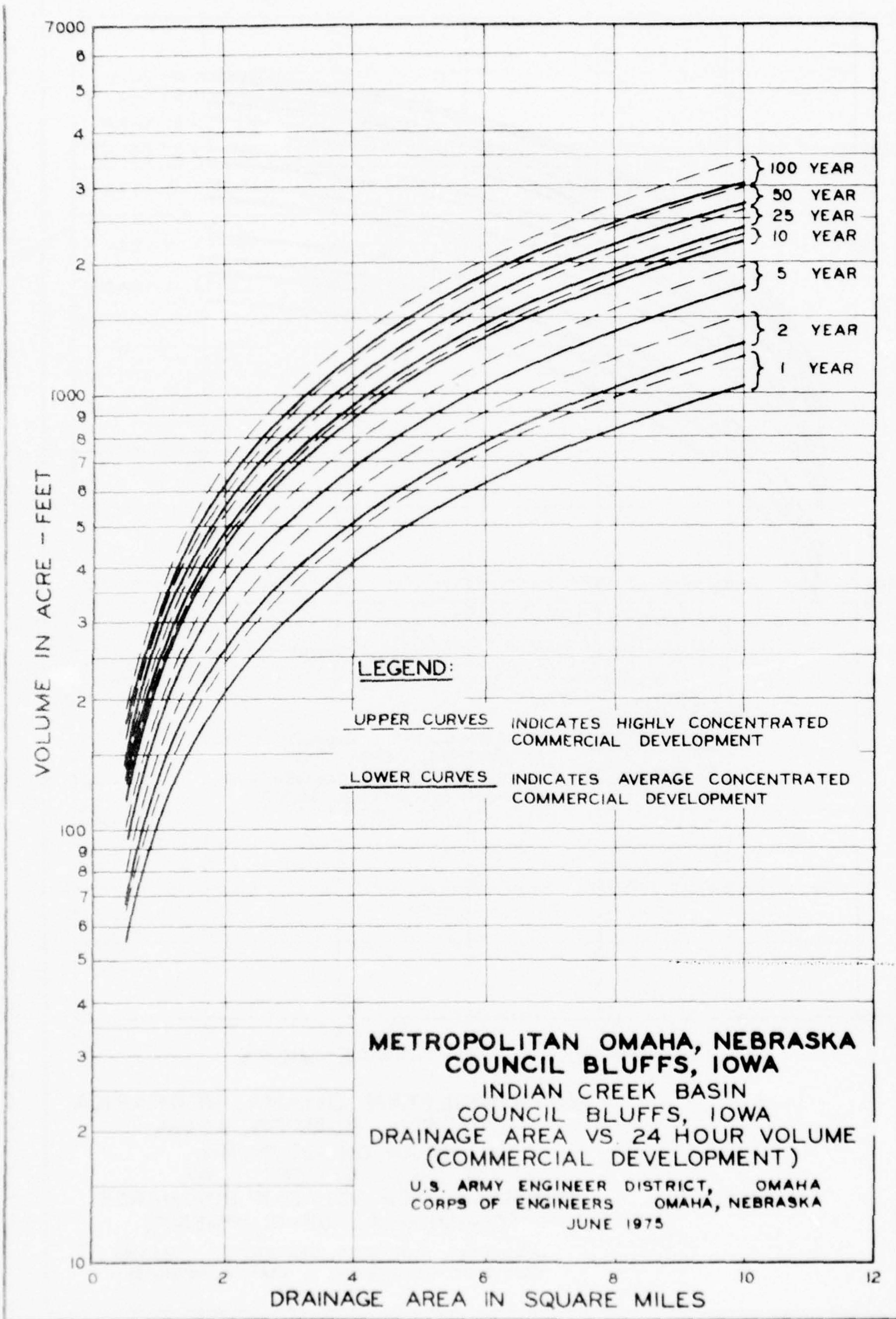
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
INDIAN CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. 24 HOUR VOLUME
RESIDENTIAL DEVELOPMENT
NORMAL DENSITY

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
INDIAN CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. PEAK DISCHARGE
(COMMERCIAL DEVELOPMENT)

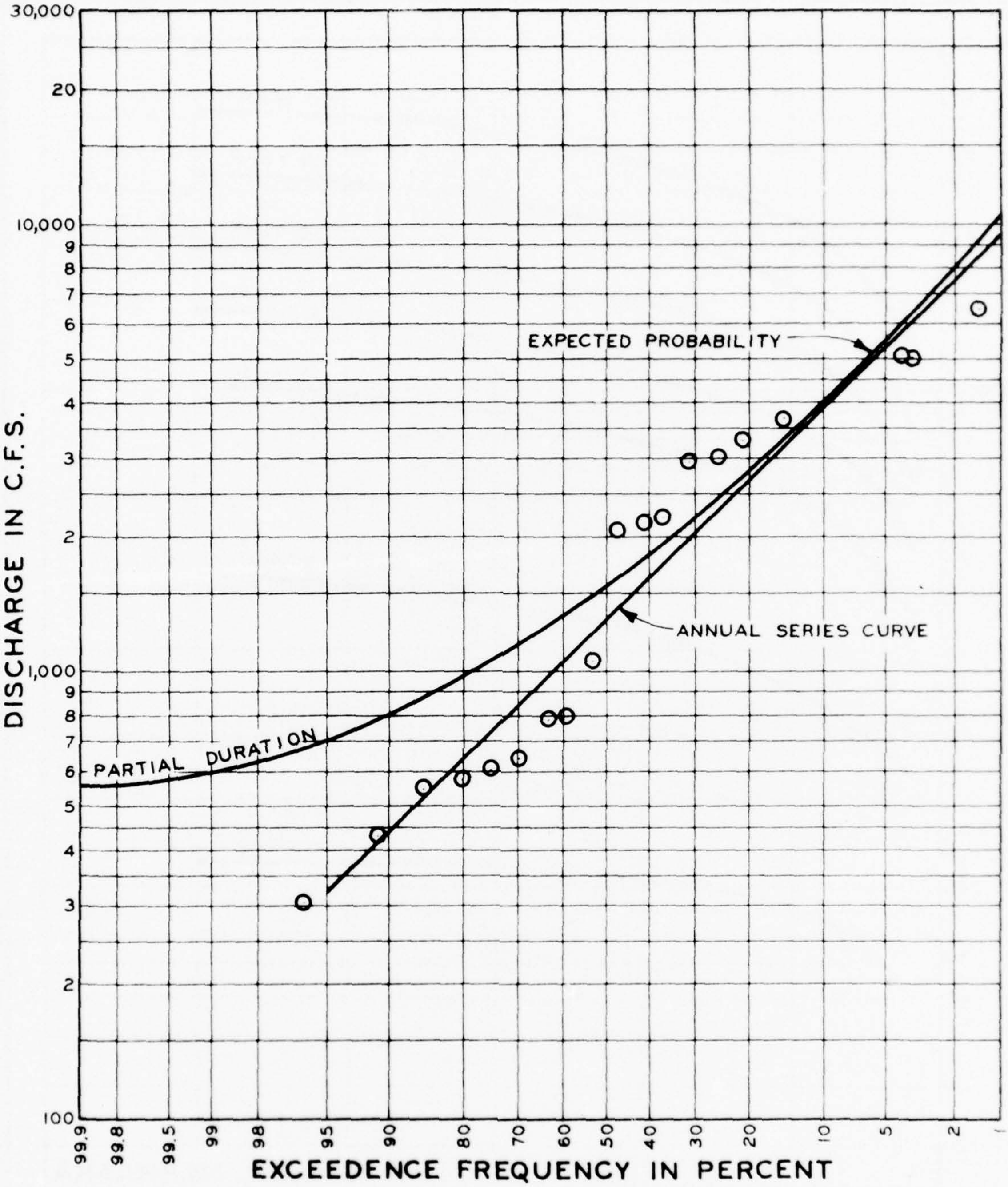
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
INDIAN CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. 24 HOUR VOLUME
(COMMERCIAL DEVELOPMENT)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

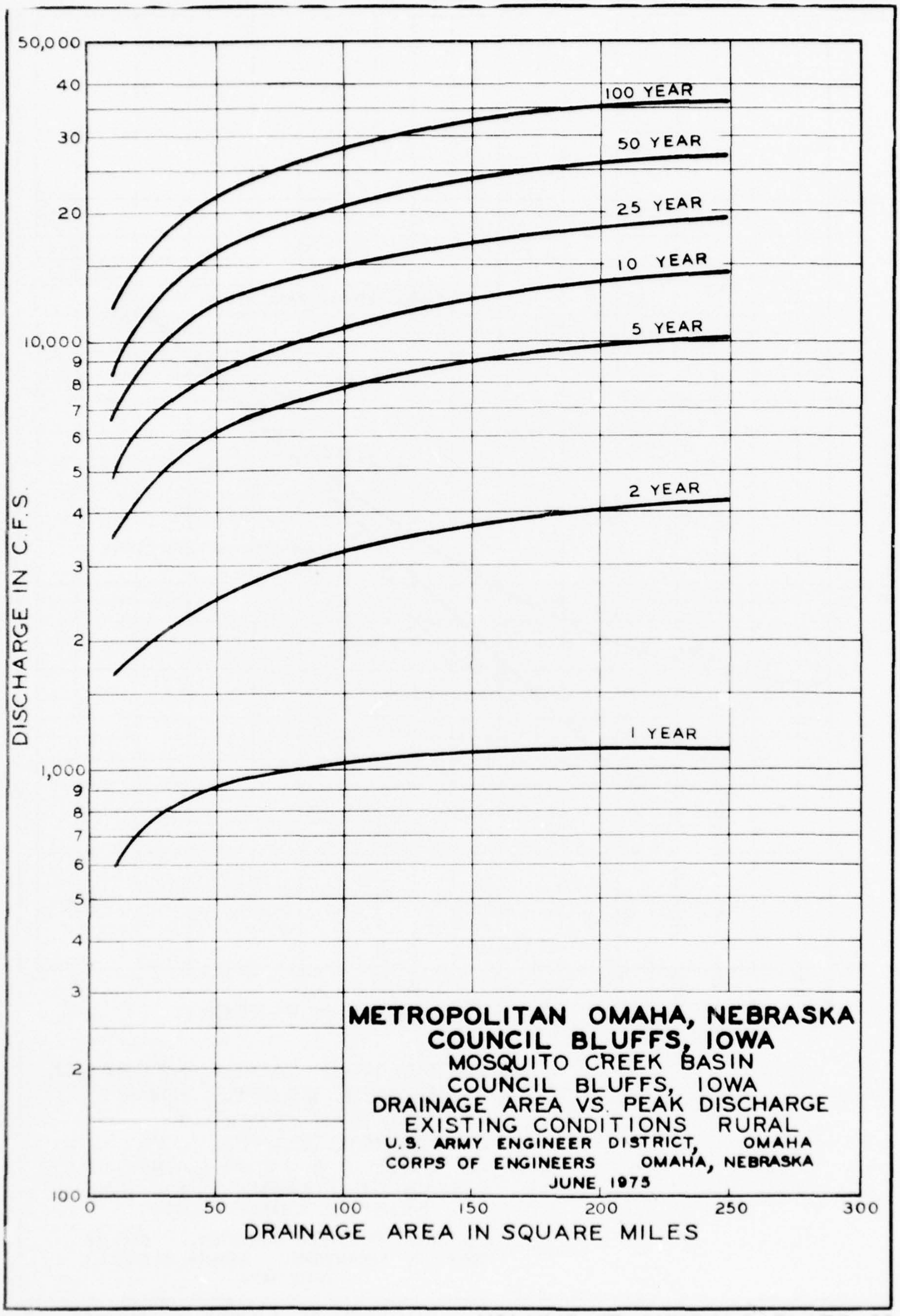
☆ U.S. GOVERNMENT PRINTING OFFICE 1972 760 646



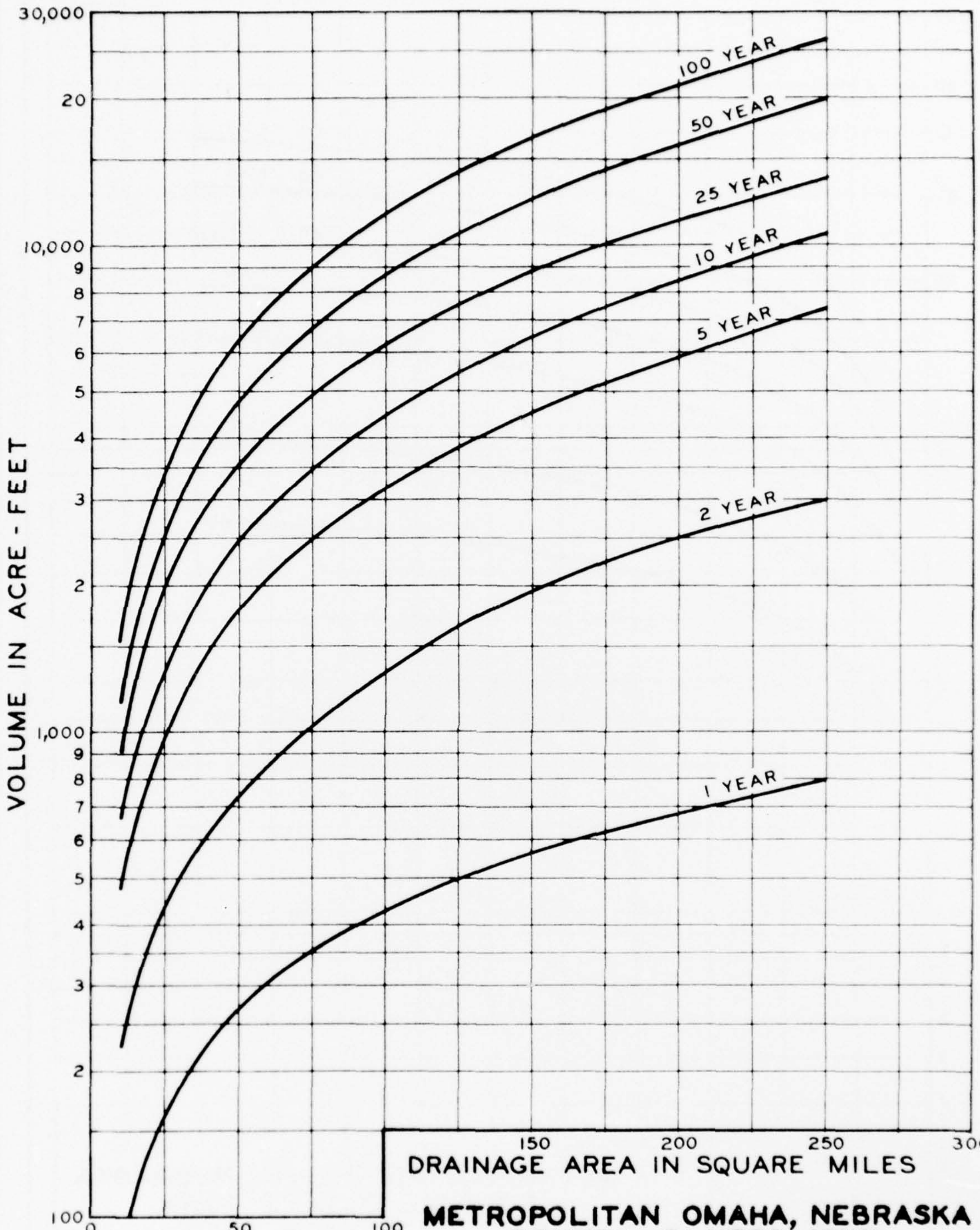
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

INDIAN CREEK AT
COUNCIL BLUFFS, IOWA
U.S.G.S. GAGE D.A. = 6.95 SQUARE MILES
DISCHARGE PROBABILITY CURVE
EXISTING CONDITIONS

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



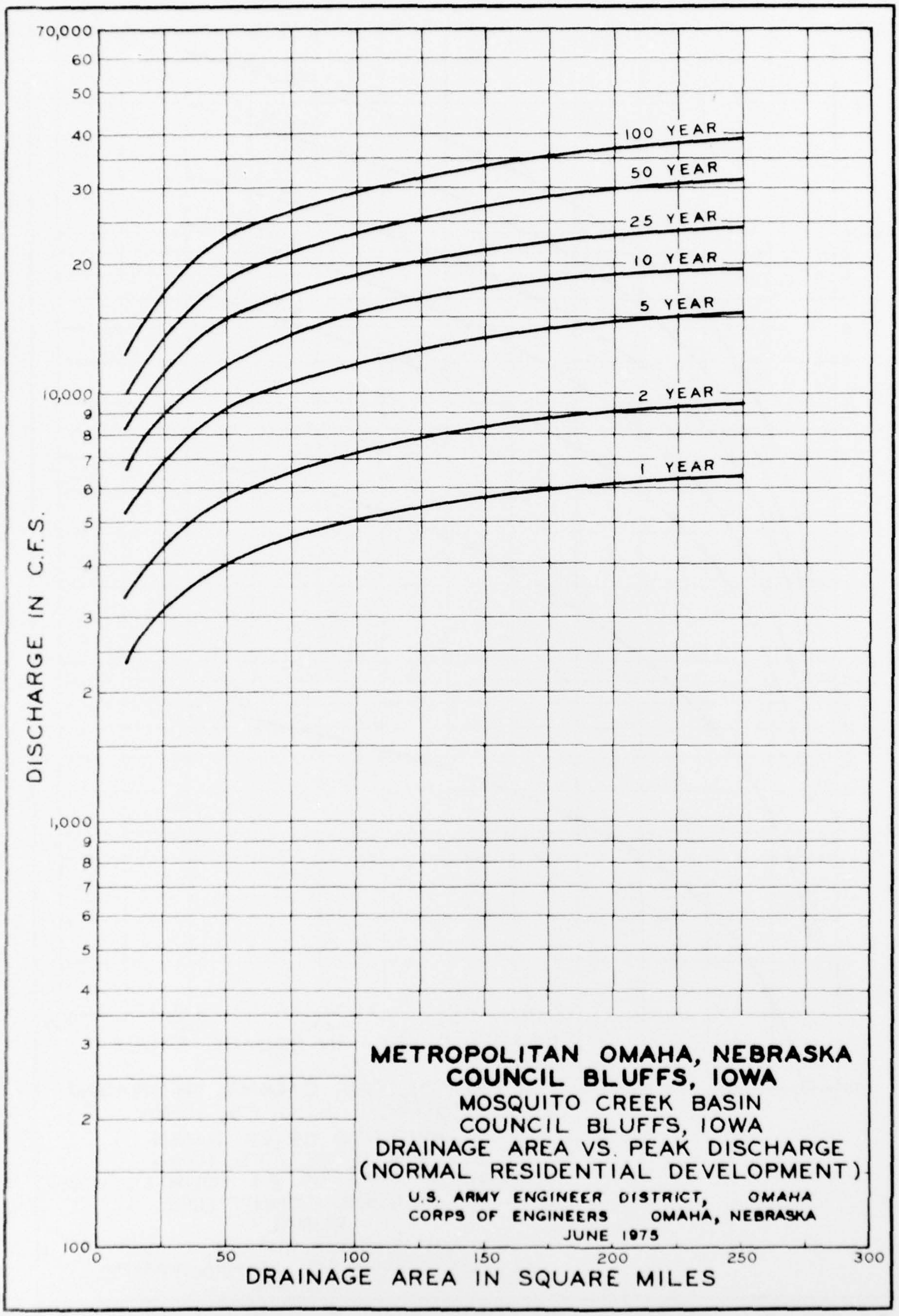
☆ U.S. GOVERNMENT PRINTING OFFICE 1972 760-646



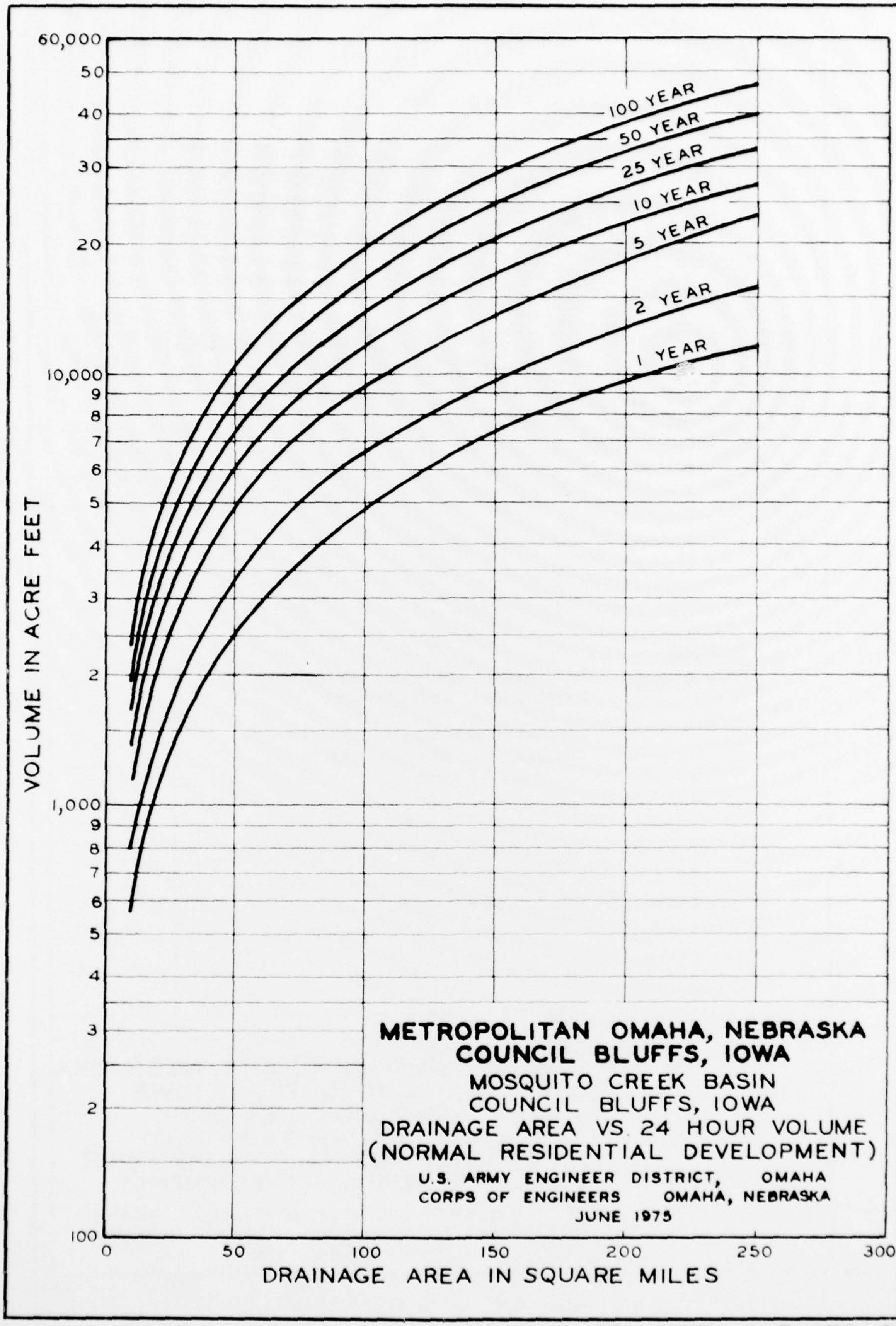
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

MOSQUITO CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. 24 HOUR VOLUME
EXISTING CONDITIONS
RURAL

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



☆ U.S. GOVERNMENT PRINTING OFFICE 1972 760 646



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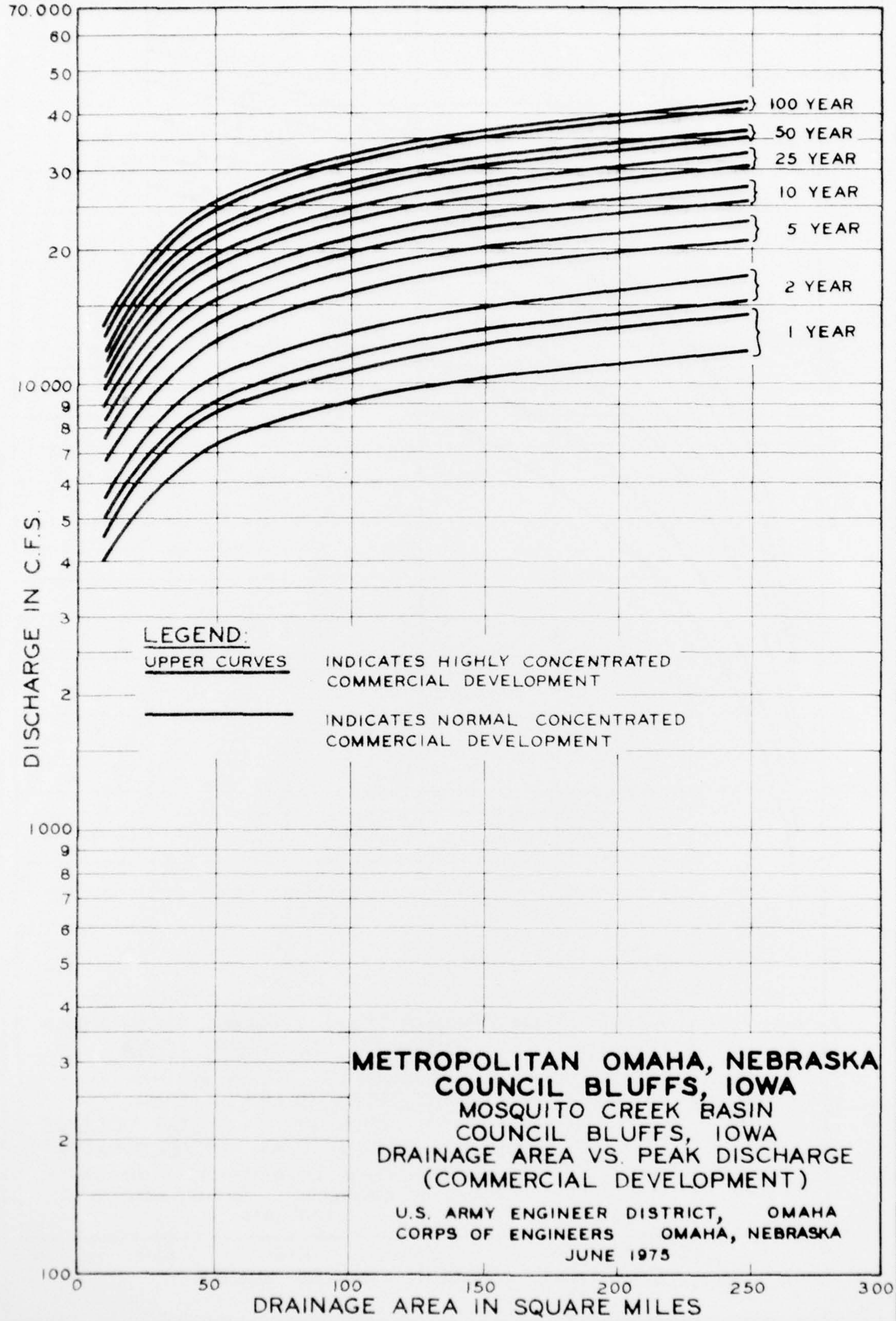
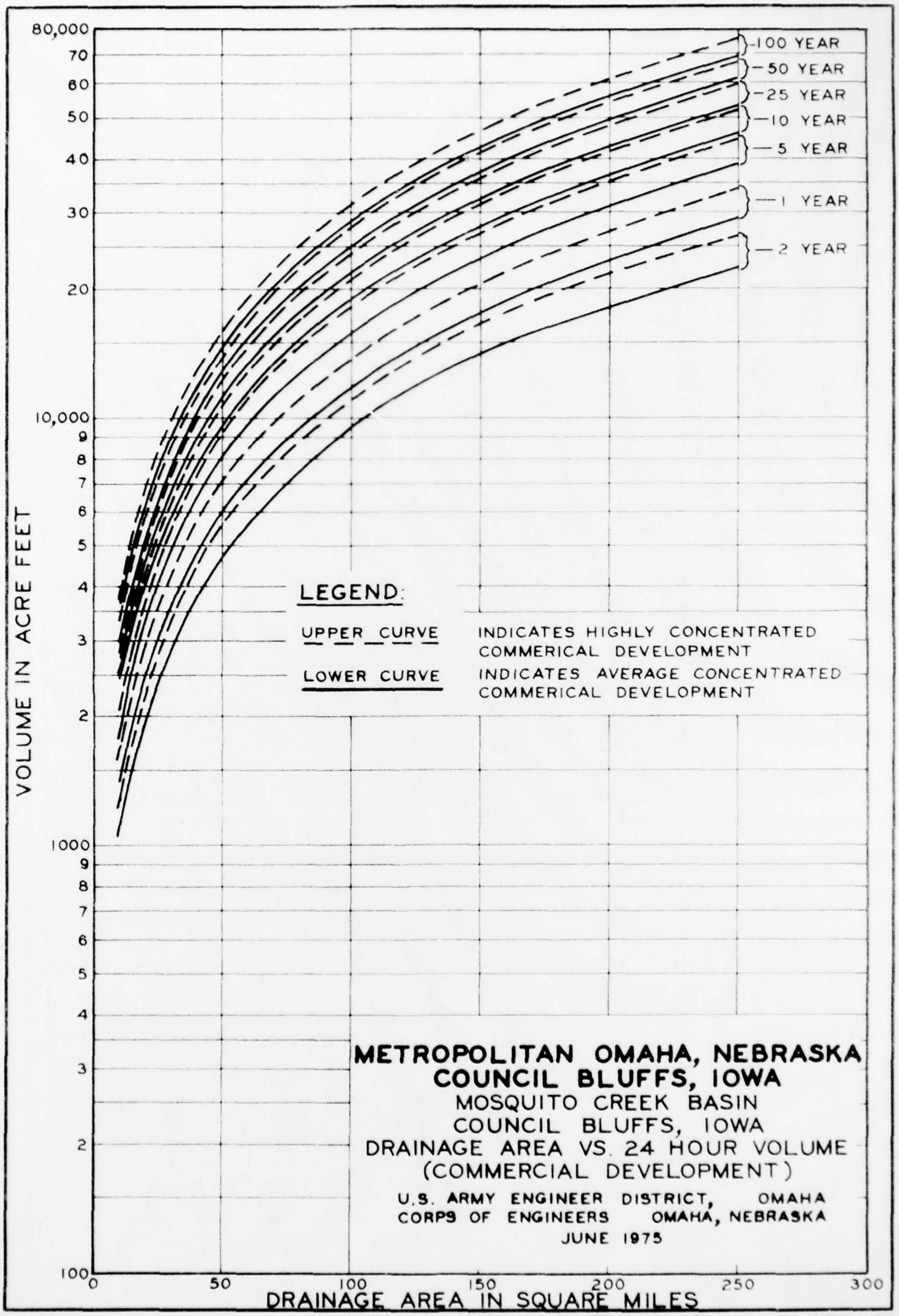
8
7
6
5
4
3
2
1,000
9
8
7
6
5
4
3
2
100
VOLUME IN ACRE FEET
0
50
100
150
200
250
300
DRAINAGE AREA IN SQUARE MILES
100 YEAR
50 YEAR
25 YEAR
10 YEAR
5 YEAR
2 YEAR
1 YEAR
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
MOSQUITO CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. 24 HOUR VOLUME
(NORMAL RESIDENTIAL DEVELOPMENT)
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
MOSQUITO CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. PEAK DISCHARGE
(COMMERCIAL DEVELOPMENT)

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

☆ U.S. GOVERNMENT PRINTING OFFICE 1972 760 646



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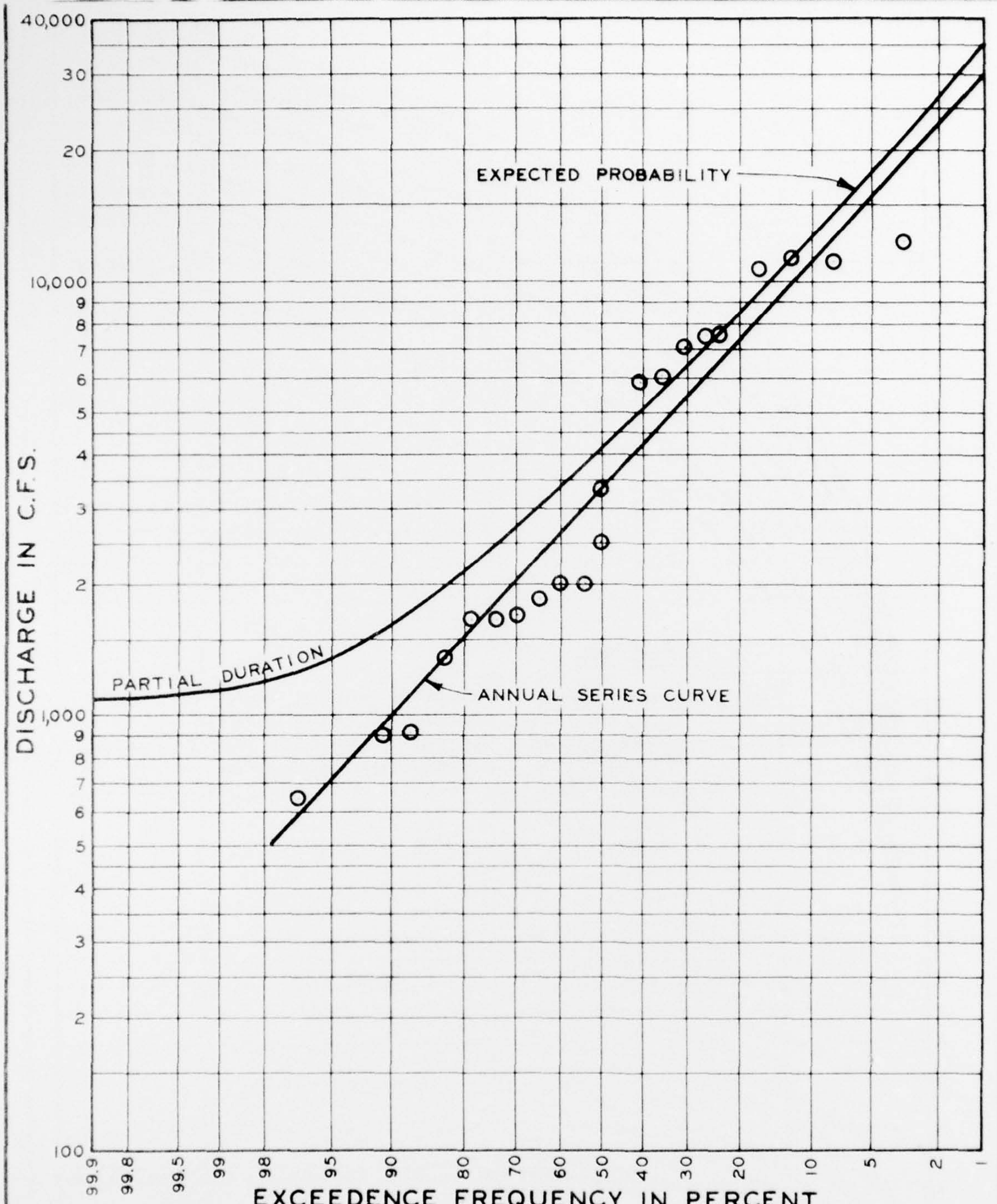
3
2
1000
9
8
7
6
5
4
3
2
100
0
50
100
150
200
250
300
VOLUME IN ACRE FEET
DRAINAGE AREA IN SQUARE MILES
-100 YEAR
-50 YEAR
-25 YEAR
-10 YEAR
-5 YEAR
-1 YEAR
-2 YEAR
LEGEND:
UPPER CURVE
INDICATES HIGHLY CONCENTRATED COMMERICAL DEVELOPMENT
LOWER CURVE
INDICATES AVERAGE CONCENTRATED COMMERICAL DEVELOPMENT
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
MOSQUITO CREEK BASIN
COUNCIL BLUFFS, IOWA
DRAINAGE AREA VS. 24 HOUR VOLUME
(COMMERCIAL DEVELOPMENT)
U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
MOSQUITO CREEK BASIN
COUNCIL BLUFFS, IOWA
CORPS OF ENGINEERS GAGE
DRAINAGE AREA - 238 SQUARE MILES
PERIOD OF RECORD 1947-1968
DISCHARGE PROBABILITY CURVE
EXISTING CONDITIONS

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

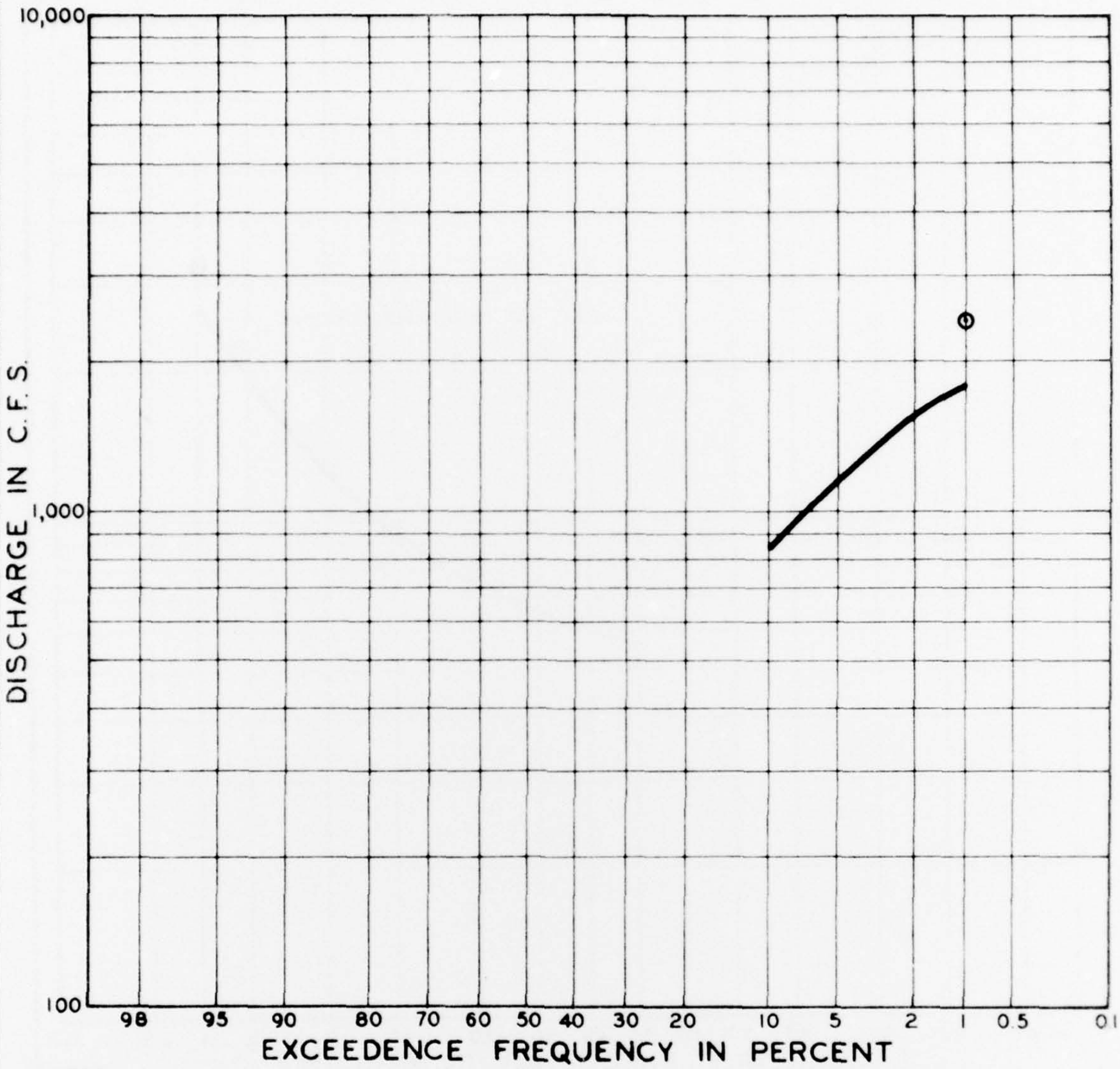
☆ U.S. GOVERNMENT PRINTING OFFICE 1972 760-646

NOTE: SUBBASIN BREAKDOWN USED FOR THE FLOOD HAZARD INFORMATION REPORT HYDROLOGIC ANALYSIS

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
BETZ DRIVE DITCH-BELLEVUE, NEBRASKA
BASIN MAP
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA

NOTE: SUBBASIN BREAKDOWN USED FOR THE OMAHA-COUNCIL BLUFFS URBAN STUDY HYDROLOGIC ANALYSIS

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
BETZ DRIVE DITCH-BELLEVUE, NEBRASKA
BASIN MAP
U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA



NOTES:

Probability curve developed for the Flood Hazard Information Report

By routing above Hwy 370
Discharges thru 1-12' x 12' RC
Box culvert @ Hwy 370

⊙ 1.0 percent flood discharge developed using the EPA stormwater runoff model

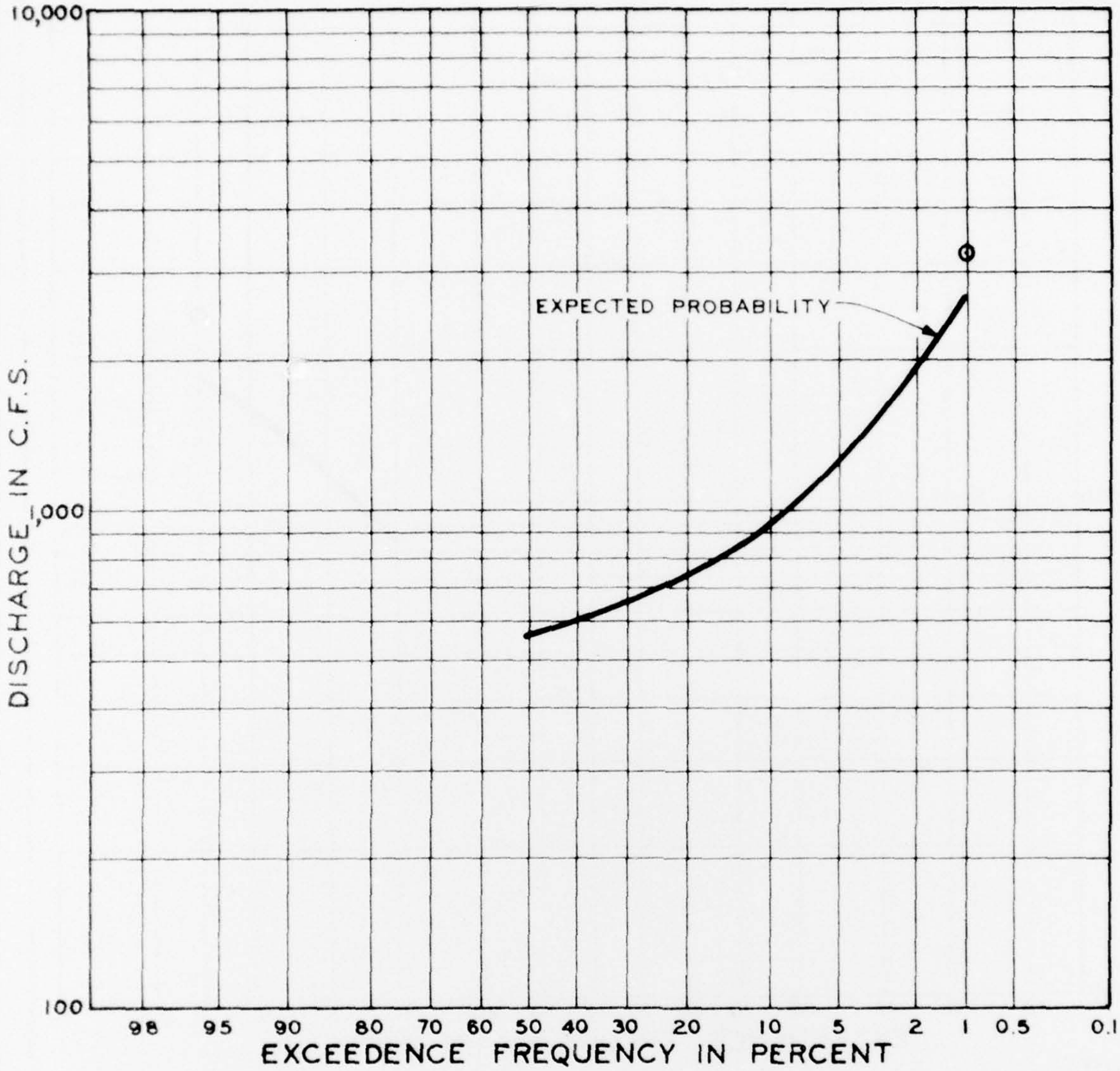
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

BETZ DRIVE DITCH BELOW HWY. 370

BELLEVUE, NEBRASKA

DISCHARGE PROBABILITY D.A. 1.67 SQ. MI.

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



NOTES:

Probability curve developed for the Flood Hazard Information Report

⊙ 1.0 percent flood discharge developed using the EPA stormwater runoff model

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

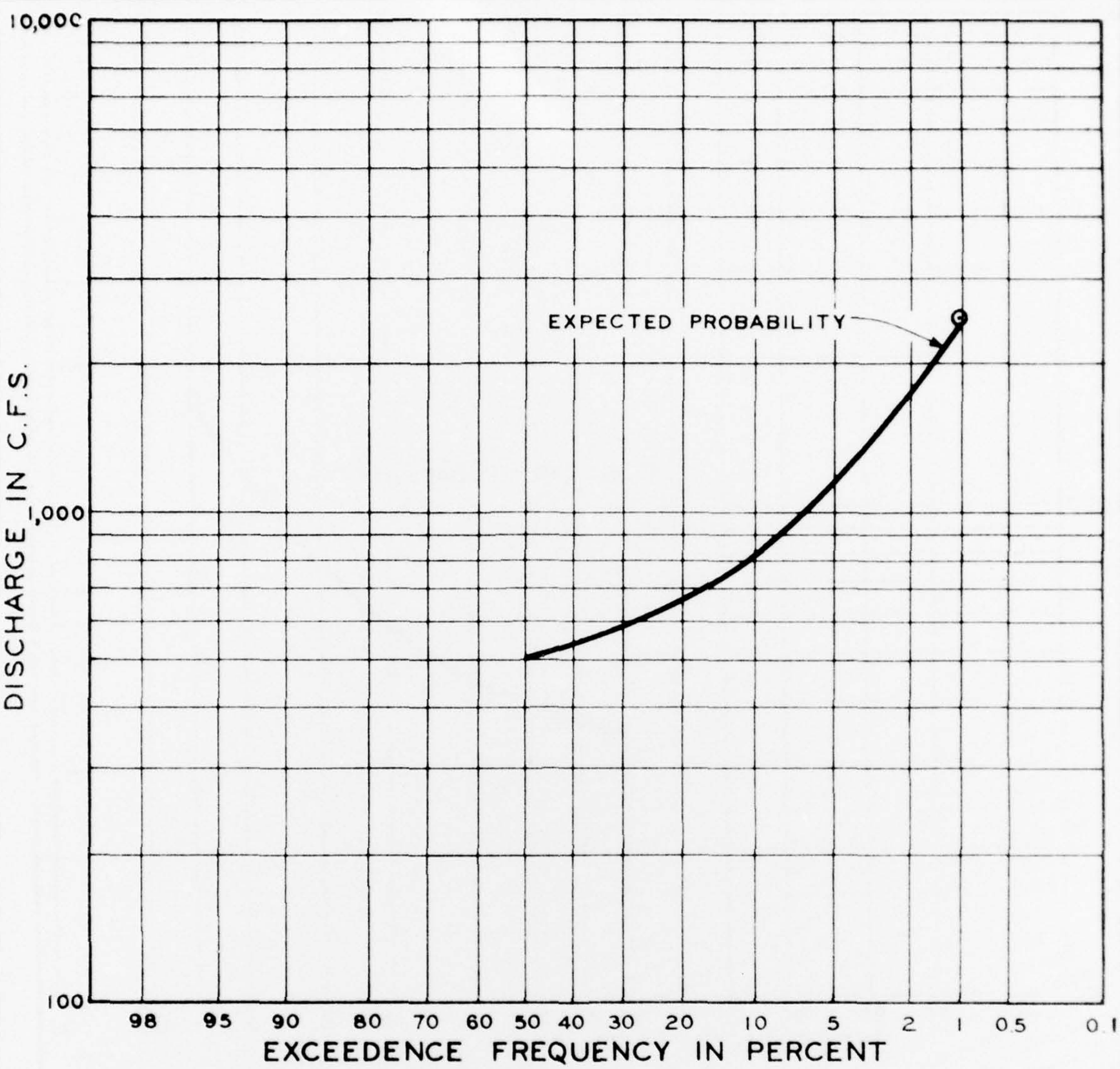
BETZ DRIVE DITCH ABOVE HWY. 370

BELLEVUE, NEBRASKA

DISCHARGE PROBABILITY D.A. 1.67 SQ.MI.

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

☆ U.S. GOVERNMENT PRINTING OFFICE 1972 760 646



NOTES:

Probability curve developed for the Flood Hazard Information Report

⊙ 1.0 percent flood discharge developed using the EPA storm-water runoff model

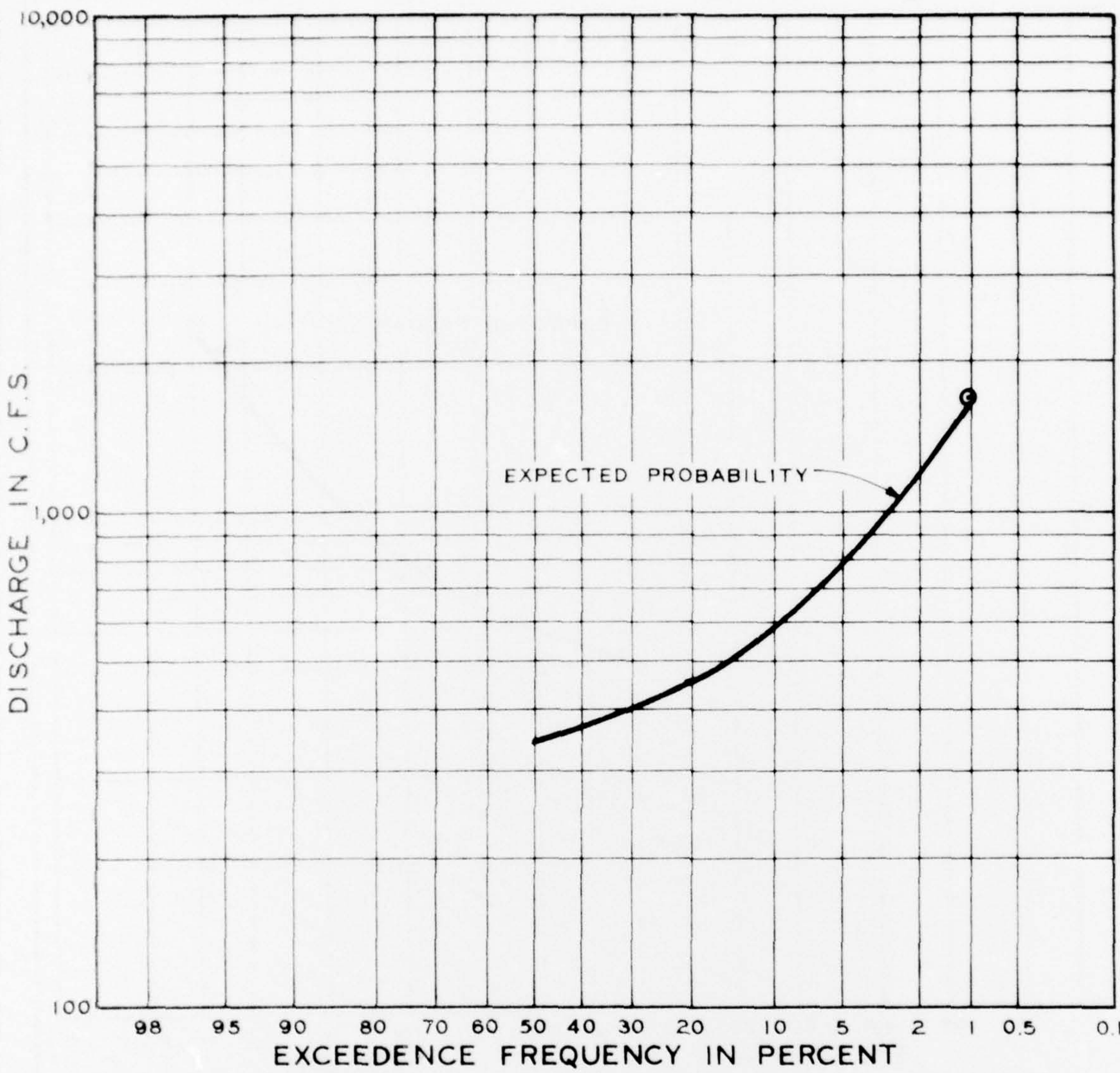
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

BETZ DRIVE DITCH BELOW JUNCTION AT LLOYD ST.

BELLEVUE, NEBRASKA

DISCHARGE PROBABILITY D. A. 1.21 SQ MI.

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



NOTES:

Probability curve developed for the Flood Hazard Information Report

⊙ 1.0 percent flood discharge developed using the EPA stormwater runoff model

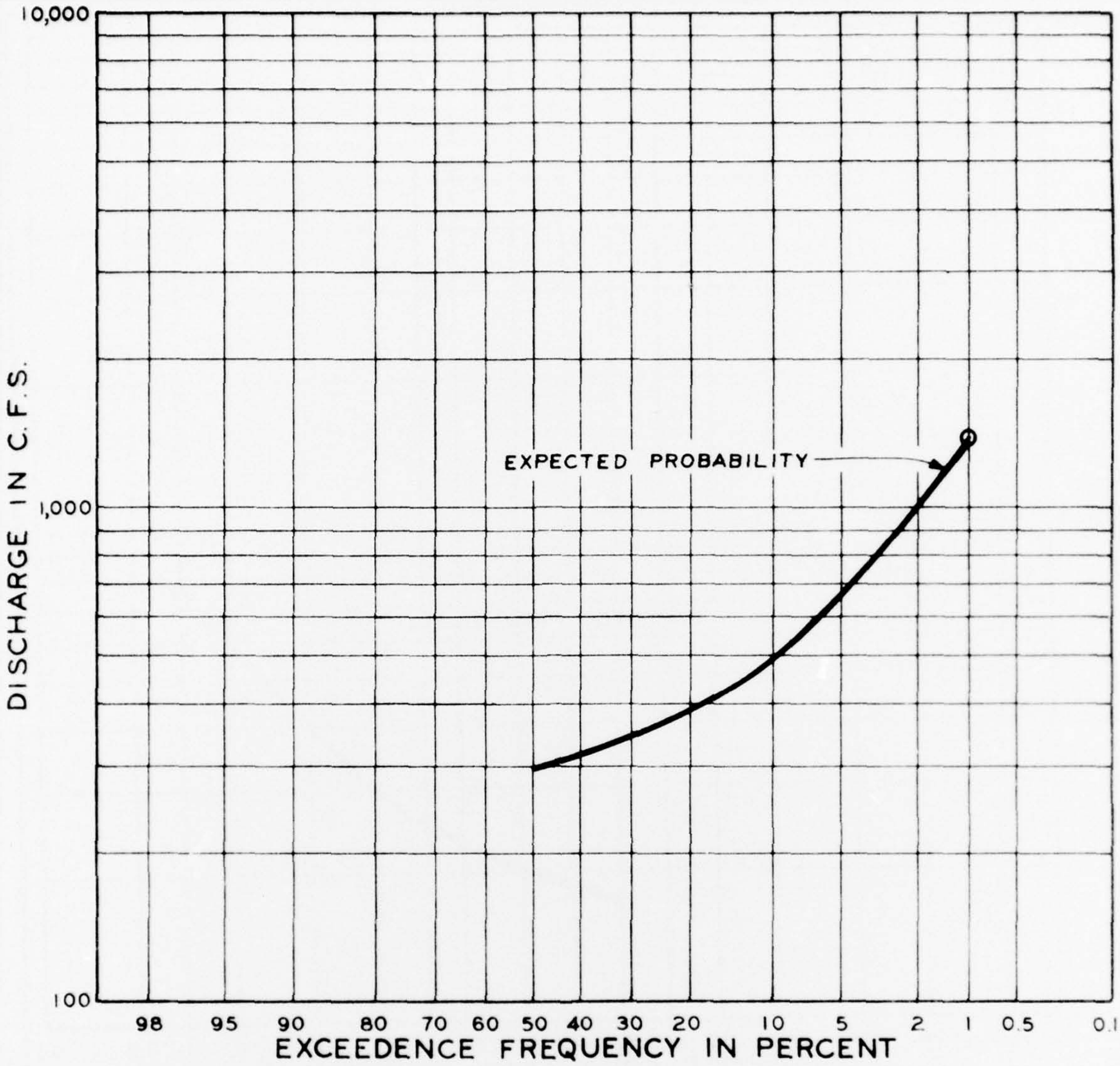
METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

BETZ DRIVE DITCH ABOVE JUNCTION AT LLOYD ST.

BELLEVUE, NEBRASKA

DISCHARGE PROBABILITY D.A. 0.82 SQ.MI.

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



NOTES:

Probability curve developed for the Flood Hazard Information Report

⊙ 1.0 percent flood discharge developed using the EPA stormwater runoff model

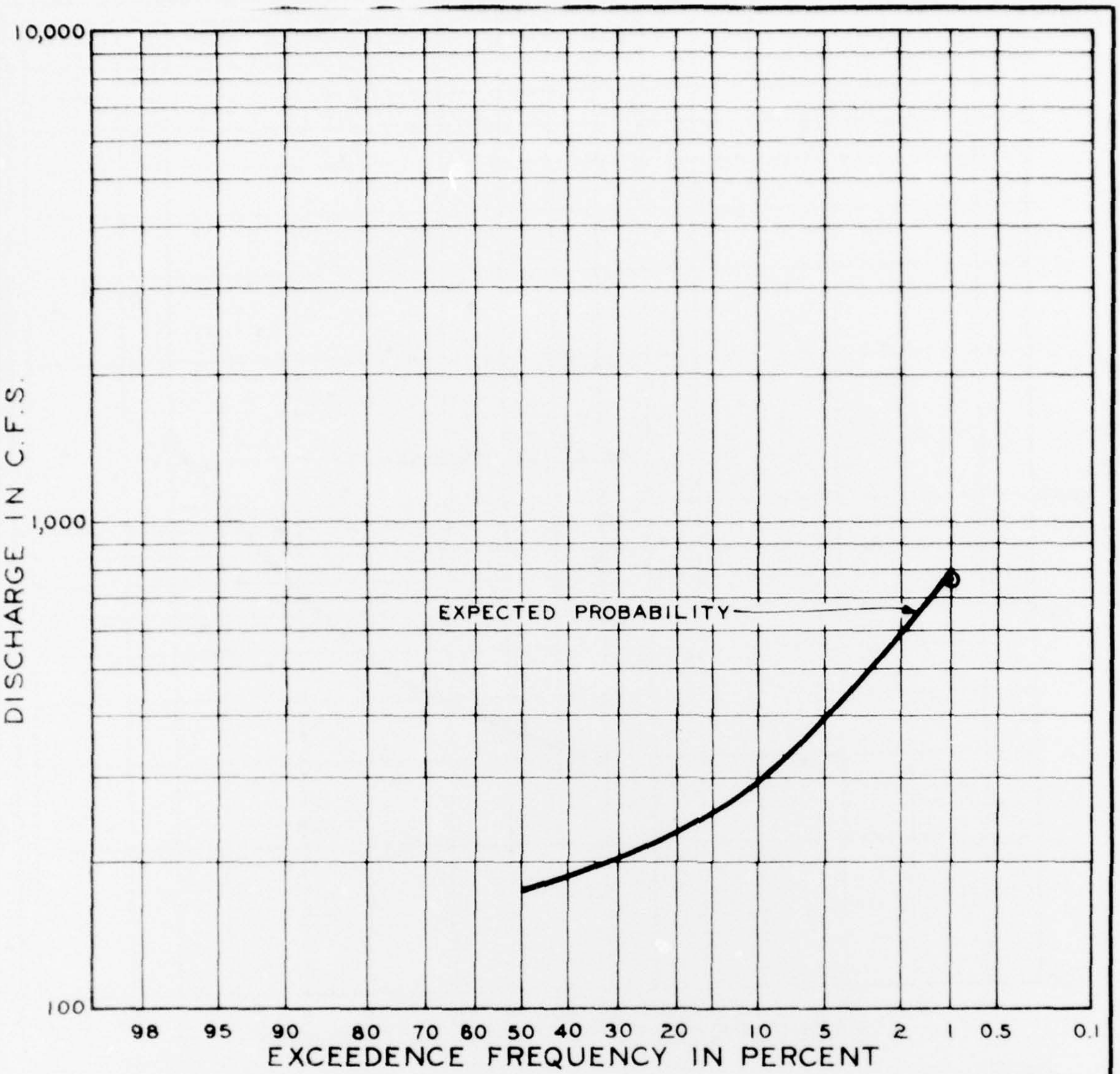
**METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA**

BETZ DRIVE DITCH BELOW JUNCTION AT LINCOLN ROAD

BELLEVUE, NEBRASKA

DISCHARGE PROBABILITY D. A. 0.45 SQ. MI.

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975



NOTES:

Probability curve developed for the Flood Hazard Information Report

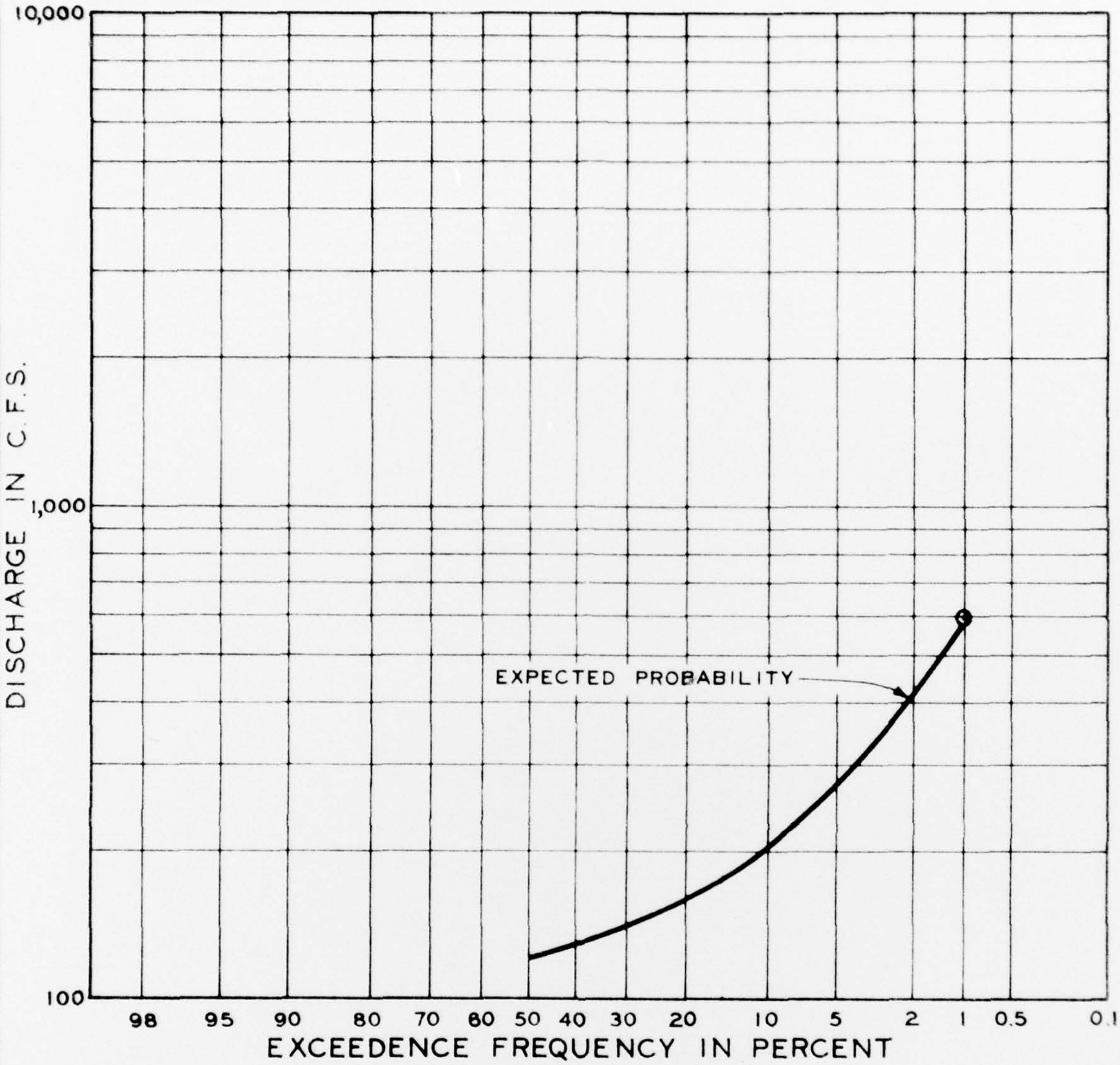
○ 1.0 percent flood discharge developed using the EPA storm-water runoff model

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA

BETZ DRIVE DITCH SOUTH BRANCH
ABOVE JUNCTION AT LINCOLN ROAD
BELLEVUE, NEBRASKA
DISCHARGE PROPABILITY D.A. 0.27 SQ. MI.

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975

☆ U.S. GOVERNMENT PRINTING OFFICE 1972 760 646



NOTES:

Probability curve developed for the Flood Hazard Information Report

⊙ 1.0 percent flood discharge developed using the EPA stormwater runoff model

METROPOLITAN OMAHA, NEBRASKA
COUNCIL BLUFFS, IOWA
BETZ DRIVE DITCH NORTH BRANCH
ABOVE JUNCTION AT LINCOLN ROAD
BELLEVUE, NEBRASKA
DISCHARGE PROBABILITY D. A. 0.18 SQ. MI.

U. S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA
JUNE 1975